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## THE RESEARCH TRAIL OF THE X-RAY<sup>1</sup>

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THE x-ray in the public mind is associated chiefly with hospitals, physicians' offices, and dental chairs. It is well known to have brought about revolutionary changes in the diagnosis and treatment of disease, and to have a place in the investigations and teaching of physics, but fewer know that the trail of research, which led down the centuries to the discovery of the x-ray, has a much wider interest and significance. As we follow it we find ourselves witnessing the early development of electricity, magnetism, and the vacuum. We are led as directly to the radio, and to other manifold applications of electricity *in vacuo*, as to the x-ray itself, and the continuation of this same trail after the discovery of the x-ray brings us to the astonishing study of radiations, to radium, to the demonstration of the electron and to those revelations of the structure of atoms which are altering so profoundly the older concepts of matter and energy.

A younger generation which has never lived in a world without x-ray and radio cannot hope to recapture that first wonder excited by these discoveries. But by retracing the winding, halting trail left by early experimentors, we will find a most fascinating story of exploration and discovery by pioneers in a world which lay

close about mankind, unknown and unsuspected until new eyes of science could be evolved to see by the light of the invisible spectrum. It is a story of the forging of new weapons against ignorance as indispensable to the advance of civilization as were the weapons of bronze that enabled man to escape from the Stone Age; a story of rare geniuses isolated from each other by long stretches of years, yet maintaining a continuity of science by the written record, and finally a curious story of the intermingling of error with insight, one no less important than the other, in forming the trail which led not only to the x-ray but also to the age of electricity in which we live.

### I

The discovery of the x-ray then is seen to be an associated result of the observations and experiments of many predecessors who left a trail of investigations leading back to sources in electricity, magnetism, and the vacuum. We shall find that the first electrical experiments were with amber, that the first observations on magnetism were with the lodestone, and that the first permanent vacuum was formed in the barometer.

Before recorded history it was known that amber, when rubbed briskly, would attract or repel chaff, feathers, and similar light objects. Seldom has a fact so important seemed so trivial and lain under-

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foot so long a time. Amber, a fossil resin found chiefly on the shores of the Baltic, was a widely carried article of trade for at least two thousand years before the scientific investigation of its properties began. Although in a class with semi-precious stones, it was not especially rare. In fact, fifteen thousand pounds of it were brought into Rome during the reign of Nero. There was, therefore, no lack of opportunity to observe the amber phenomenon, yet this excited only idle curiosity in the great minds of antiquity. Finally it was the analogy of this strange power to that of the lodestone to attract iron which led to its first scientific study by Gilbert, only three hundred years ago.

A knowledge of the lodestone had to wait until iron was discovered and worked. Lodestone, an iron ore which is naturally magnetic, was widely distributed in the Mediterranean islands and adjacent lands. It is, in fact, a common ore found in many countries and is the source to-day of a large percentage of the world's iron. Certain masses of this ore were discovered to be especially magnetic and were highly valued in early times. One of the largest of historic interest, prepared by Galileo for the Duke of Tuscany, weighed five pounds, was able to lift four times its own weight, and was valued at four hundred crowns. Lodestones were puny playthings compared to the powerful electromagnets of the present day but, as natural means of stimulating early research, they were beyond price.

Dr. William Gilbert, physician to Queen Elizabeth, an enthusiastic convert to the Copernican hypothesis, conceived the idea that the earth and other heavenly bodies were huge magnets held in their orbits by the same attraction as that exhibited by the lodestone. To prove his theory he began experiments which soon carried him into unexplored regions. He was a busy practitioner in London and became president of the Royal College of Physicians, yet for a period of eighteen years he applied himself to this task, spending upon it a considerable portion of his income

without thought of pecuniary reward. But Elizabeth, although scornful of doctors even on her death-bed, remembered Doctor Gilbert with the only substantial bequest left to any of her personal attendants. The great Queen, fierce of will, with prophetic insight, gave to research a recognition which, though insignificant compared with modern endowments, still has power to stir our admiration.

In a lesser age Gilbert might not have been ignored so frequently by general historians, but his was the age of Shakespeare and Francis Bacon. It was the age when England was curbing the Spanish Empire in the New World and when the Invincible Armada was met and shattered. But while Hawkins and Drake were becoming great sea captains, and Raleigh was planting colonies in America, Gilbert in his laboratory was exploring another kind of a new world and definitely opening the trail that was to lead to the electrical development of the present day. His work may be said with truth to have contributed more to human progress than any of the picturesque exploits of his time.

"De Magnete" of Gilbert was a book famous even in his own day. That the appreciation of this work has grown with increasing knowledge, was shown by the formation of the Gilbert Society, with Lord Kelvin as its first president. This Society produced a translation of "De Magnete" from Latin into Elizabethan English, and revealed Gilbert as a vigorous writer quite able to fight his own battles, as may be seen from his preface: "...Why should I, I say, add aught further to this so-perturbed republic of letters, and expose this noble philosophy which seems new and incredible by reason of many things hitherto unrevealed, to be damned and torn to pieces by the malediction of those who are either already sworn to the opinions of other men or are foolish corrupters of good arts, learned idiots, grammaticists, sophists, wranglers, and perverted little folks? But to you alone, true philosophers, honest men who seek knowledge, not from books only but from things them-

selves, have I addressed these magnetic principles in this new sort of philosophizing."

We see that Gilbert exemplifies in his own work the inductive method associated with the name of his contemporary, Francis Bacon. He also clearly anticipates Sir Isaac Newton in the matter of gravitation, explaining that ships and people do not fall off the planet because of the attraction of all bodies by the great mass of the earth. He states clearly that this is what is called weight and perceives that the same attraction is present in other celestial bodies. He says: "So lunar things tend to the Moon, solar things to the Sun, within the orbs of their own effluvia."

One of Gilbert's most striking experiments was with his *terrella*, or earth-kin. The *terrella* was a large lodestone in the form of a ball to represent the earth. Every lodestone, whatever its form, has two poles, the same as any other magnet. A magnet made of a steel bar can be bent so as to bring the two poles near together, as in the case of the common horseshoe magnet. But in the form of a ball, the poles are necessarily opposite. Gilbert gave careful directions for ascertaining the location of these poles. The *terrella* was then supported at the poles so that it could be turned on an axis, like a library globe. A compass needle on the surface of this *terrella* would then point to the poles, no matter how the ball was turned, exactly as on the surface of the earth. When the needle approached a pole it would dip. This has been found to be the case with the earth, and by means of the dipping-needle the magnetic north pole has since been ascertained not to coincide with the axis of the earth. If Gilbert had known this he could have mounted his *terrella* to correspond. Nevertheless it remains to-day a marvelous demonstration, although not accepted as an explanation of gravitation.

It was Gilbert who first used the word "electrical," from the Greek for *amber*, to apply to properties of attraction arising from friction. He classified all bodies as

electric and non-electric. He little thought that his experiments with frictional electricity would outvalue his elaborate theories of magnetic gravitation. But he had supplied a method of investigation, a scientific recognition, a classification, and a name for phenomena which before his time were thought scarcely worthy of serious attention.

These phenomena happened to be the effects of high tension electricity, although in minute quantities, and this happened to be the form of electricity capable of exciting a vacuum—the one circumstance which determined the direction of the x-ray trail. Furthermore, this static electricity was the only form known until the discoveries of Galvani and the construction of the battery by Volta, in the closing days of the Eighteenth Century. But still static continued to be the only form of high tension electricity until some forty years later, when the co-discovery by Faraday and Henry of electromagnetic induction led to the invention of the coil, the dynamo, and the transformer.

An evaluation of facts is not to be expected of the pioneer investigator. Gilbert studied electricity because an electrical effect simulated magnetic attraction. He studied magnetic attraction because, to his mind, this simulated the attraction of the earth and other celestial bodies. He was inspired in his experiments not by simple facts but by a great astronomical theory, as was also von Guericke, who came after him. Indirection is an interesting characteristic of research and the neglected fact often is found later to lead to a treasure lying unsought and quite unsuspected. Never was this truth better exemplified than by Gilbert and his successors.

At this point, our research trail is recurrent, turning backward to the Thirteenth Century, to an ancient Latin manuscript on the magnet, from which Gilbert had borrowed freely. This is the famous "Letter of Peregrinus" (1269), first translated into English by Sylvanus P. Thompson, secretary of the Gilbert Society before

mentioned. This letter (*Epistola ad Sigerum*) was written in the trenches while Peregrinus was engaged as a military engineer of the French army at the siege of Lucera, in southern Italy. It was sent to his friend Sigerus de Fenicancourt, in his native town of Maricourt, France. He begins: "Dearest of Friends; At your earnest request, I will now make known to you, in an unpolished narrative, the undoubted though hidden virtue of the lodestone." Whereupon he launches into a treatise of 3,500 words, divided into chapters and avowedly intended to form a part of a larger work which, however, was either lost or never completed.

Peregrinus gave an orderly arrangement of Thirteenth Century knowledge of magnetism and added new discoveries and inventions of his own, including the first compass to be pivoted and to be provided with a meridian scale, practically as we have it to-day. Here we find the origin of Gilbert's *terrella* and also the description of the first magnetic motor ever proposed—the first far cry of the dynamo and the mechanical prophecy of an electric current.

We had no further knowledge of Peregrinus until the astonishing works of Roger Bacon, his contemporary, were resurrected after an interment of over five hundred years. Bacon, a courageous thinker and investigator, had been thrown into prison and his works suppressed by the Church. In his "*Opus Tertium*," brought to light in 1859, Bacon calls Peregrinus one of the "two perfect mathematicians" of his day, and continues: "He is a master of experiment. Hence, he knows all natural science whether pertaining to medicine and alchemy, or to matters celestial and terrestrial. He has worked diligently in the smelting of ores as also in the working of minerals; he is thoroughly acquainted with all sorts of arms and implements used in military service and in hunting, besides which he is skilled in agriculture and in the measurement of lands. It is impossible to write a useful or correct treatise in experimental philoso-

phy without mentioning this man's name." It is all but obvious that Peregrinus had written larger works which were less fortunate than Bacon's in being resurrected. However, the letter remained. Manuscript copies were passed from scholar to scholar, twelve still being preserved in European libraries. A later printed copy in the British Museum penciled by the famous (or infamous) Dr. John Dee, "favorite astrologer" and confidential agent of Queen Elizabeth, proves that it was known to English scholars of Gilbert's time, although Gilbert does not mention it. We see, in this letter of Peregrinus, the scientific source of the magnetic branch, which in "*De Magnete*," of Gilbert, joins with the electrical branch to form our research trail. The third branch, that of the vacuum, is now to be traced.

## II

Contemporaneous with Gilbert was that mighty figure, Galileo, also a physician, who set in motion new intellectual currents by revolutionary discoveries in astronomy and experimental physics. He had felt the heavy hand of the Church but in far-off Germany he influenced a man who was to take us a surprising distance on our journey. This was the famous burgo-master of Magdeburg, Otto von Guericke, another ardent disciple of Copernicus, who began his work about forty years after Gilbert. Although not an astronomer, he first predicted the periodic return of comets. But what was of more practical importance, he reasoned that the earth, moon, and other heavenly bodies observed through the telescope of Galileo, must be moving in empty space, else the resistance of air would long since have brought all to a standstill. Acting on this idea, he made the first air-pump in the world, for the distinct purpose of forming a vacuum so as to study celestial conditions close at hand. Again, as is usual in research, his success was in unforeseen directions and led to unexpected conclusions.



Von Guericke was a man of such political importance that his experiments could not but excite marked public interest. The King of Prussia was his friend and protector. One of his demonstrations before his royal patron was with the celebrated Magdeburg Hemispheres which he had devised. These were halves of a heavy metal sphere which would fit together so as to be air-tight, a stopcock enabling him to pump out the air. Heavy rings on each hemisphere could be attached to chains. An old print shows eight horses hitched to each hemisphere and being made to pull in opposite directions. The sixteen horses could not pull the hemispheres apart, yet, as soon as von Guericke turned the stopcock and let in the air, they fell apart of themselves.

Von Guericke recognized that air had weight and invented an air-balance. By measuring the weight of the atmosphere, but without knowledge of the Torricellian barometer, he was able to make extraordinary weather predictions and may be said to have founded the science of meteorology. He found that animals could not live in a vacuum and that all bodies, feathers and stones alike, fell with equal velocities therein. He made numerous other experiments which belong to the history of physics, but what interests us still further in the achievements of this remarkable man is his invention of the first electrical machine. This was a large ball of sulphur, supported on an axle, with a handle by which it could be rapidly turned. When the dry hand was held to the revolving ball, sparks were produced—a discovery of pivotal importance.

However, von Guericke's mind was pre-occupied by the theory of Copernicus. He found that the excited sulphur ball would attract all sorts of light objects, thus exhibiting a different and more universal attraction than the lodestone. It was, in effect, a non-magnetic terrella without poles. He arranged a tray beneath his sulphur sphere, on which he scattered bits of paper, shavings, particles of gold and

silver leaf, chaff, etc. When the ball was stroked with the dry hand and turned, these fragments were attracted and clung to the revolving globe, which to von Guericke simulated the attraction of the earth. He saw that this attraction was communicated over a linen thread a yard in length—really the first transmission of an electrical impulse over a conductor—though he did not perceive this to be an impulse or a current. He had produced a vacuum as a specimen of interstellar space, but it never occurred even to his fertile mind to excite it by sparks from his electrical machine. He little thought that these sparks which he drew from his electrified sulphur ball were to prove of greater importance than his fanciful demonstration of terrestrial gravitation. He had, indeed, illustrated his conception of the earth as a huge ball "rotated by the Hand of the Almighty and excited by the friction of the solar rays," but he was unmindful of the electric giant that so gently touched his hand. Here again a pioneer unknowingly trod the path to discovery with his eyes fixed on an *ignis fatuus*.

Like Peregrinus, von Guericke was a military engineer. In this capacity he had followed the fortunes of Gustavus Adolphus, the Lion of the North. He was a many-sided man, had studied law in Leipzig and other schools, and mathematics in Leyden. He had travelled extensively, and was a scholar with a strong bent toward science and philosophy. He returned to his native city of Magdeburg and shortly after, at the age of forty-four, became burgomaster, which position he held for thirty-five years. During this period he made his experiments and discoveries, the most original and important of his time, and composed his great work, "De Vacuo Spatio," in Latin. This was published in 1672 when von Guericke was seventy years of age; but an earlier account of his work, by Kaspar Schott, appeared in 1657 and inspired Boyle to experiments which made him the most celebrated English scientist of his time.

## III

Robert Boyle, youngest son of the Duke of Cork, was the most highly gifted of a family noted for famous men, and spent a long and brilliant career devoted to physical experimentation, largely with the vacuum and with that mysterious property of attraction and repulsion which Gilbert named after amber. Although he made no step ahead on the trail of electricity, he advanced the study of the vacuum. Boyle deserves notice also as one of the founders of the English Royal Society, which was to play a major rôle in so many of the discoveries to be related.

This great Society granted a living to selected men who wished to devote their time to research and invention. The first of these "Curators of Experiment" was Robert Hooke, one of the most astonishing geniuses of any age. It now appears that a large number of the scientific discoveries and theories of the time of Boyle and Newton were the work of Hooke. His versatile mind took all science for its province. Thin, deformed, with an ugly temper, he became a misanthrope who saw his discoveries continually appropriated or misunderstood. He was a shrewd financier, and after his death an iron-bound chest was found in his lodgings, containing a fortune in gold and securities whereby he had hoped to found an institution for the development of his discoveries and inventions. However, having neglected to make legal provisions, his dream never came true. Nevertheless Hooke by method, apparatus, and discovery endowed the experimentalists who came after him, and his passing brings us to the most important figure in the early history of electrical exploration.

This figure is Francis Hauksbee, who followed Hooke as one of the Curators of Experiment to the Royal Society. Like Hooke, he combined inventive genius with exquisite mechanical skill, and an inquiring intelligence with that vein of originality necessary for scientific discovery. He had inherited, in a sense, the air-pump and the

vacuum which Boyle and Hooke had derived from von Guericke, and he proved to be a worthy successor to these pathfinders. While both von Guericke and Boyle had experimented with frictional electricity as developed by Gilbert, yet it remained for Francis Hauksbee to bring electricity and the vacuum together for the first time by intent and design. This achievement was the indispensable step, and the longest step, on the trail that led to the x-ray and its manifold results; to radio and worldwide communication; to incandescent and neon illumination, and to all the other multitudinous electrical inventions depending on vacuum tubes.

To trace the succession of events leading to Hauksbee's experiments requires a detour to strike a contributory trail, again arising in Italy. Galileo, in his blind old age, found himself greatly interested in the writing of a young genius, Evangelista Torricelli, whom he invited to Florence to become his secretary and companion. When this happy relation was terminated a few months later by the death of the master, Torricelli was made his successor to the chair of mathematics in the Academy of Experiments (*Accademia del Cimento*) by the Grand Duke of Tuscany, who deserves fame as the patron and protector of Galileo. Torricelli thought out an explanation of one of Galileo's unfinished problems, namely, why a pump cannot draw water higher than about thirty-three feet. He reasoned that if it were the weight of the air which forced up the column of water with each lift of the piston, then the atmosphere could sustain a column of mercury only one-fourteenth as high, because mercury is fourteen times heavier than water. He proposed to fill with mercury a glass tube so that it would stand upright, with the open end immersed in a cup of mercury. This experiment was actually made, not by the hand of Torricelli, but by one of his pupils, Viviani. The mercury column sank to about thirty inches, leaving an empty space above. Thus, in 1643, was invented one of the most important of scientific in-

struments, later named by Boyle the barometer. However, it was the empty space above that was to prove the more important to our trail, because this was the first permanent vacuum, antedating von Guericke and his air-pump by about five years. Torricelli was too busy with his mathematical studies to publish his invention of the barometer, but described his experiments in two letters to his friend, Ricci, in Rome. In these letters, which are still preserved, he makes clear that his final purpose was "not simply to produce a vacuum but to make an instrument which shows the mutations of the air, now heavier and dense and now lighter and thin."

Research picks its devious way in unpredictable directions and without regard for the flight of time. Jean Picard, French priest and astronomer, forever famous as the savant who supplied Sir Isaac Newton with the calculations necessary to prove gravitation as a law of the universe, is also famous for an observation which must have seemed to him of trifling importance. One night, thirty-five years after Torricelli's experiment, Picard chanced to carry his barometer up some steps and noticed in the dark that the vacuum of the instrument became luminous. He found that he could produce the glow at will by agitating the mercury. As befitted a true scientist, he recorded this observation. A fact, once recorded, can bide its time. Twenty more years passed when Bernouilli, a German professor of mathematics, in reviewing some of Picard's calculations, came upon these notes on the barometer. He did some experimenting of his own by shaking mercury in tubes with and without a vacuum. He produced considerable light, which he called "mercurial phosphorus," and believed that he had invented a mechanical substitute for candles. The Picard glow, the strange light in the first vacuum, which in Bernouilli's hands became the unsuspected beginnings of the electric light, was destined henceforth to illuminate the research trail of the x-ray.

When the report of Bernouilli's experiments reached the Royal Society we are transported again to England, where Francis Hauksbee was beginning the investigation of "mercurial phosphorus." This was the subject of his first paper as Curator of Experiments. Instead of working with a miniature vacuum chamber in the end of the barometer, he exhausted much larger tubes and bell-jars by means of an air-pump of his own design. He finally demonstrated that the Picard glow, or Bernouilli's "mercurial phosphorus," was due to the friction of mercury on glass, which produced electricity.

Once started on this line of investigation, a limitless field opened before him. He made tubes within tubes so that either could be exhausted separately. He invented a small friction machine, the first of its kind, which he operated within an exhausted bell-jar. He built machines for the rapid rotation of vacuum bulbs six or eight inches in diameter and found that the friction of his dry hand on the outside of these globes gave the most brilliant luminescence. A quiescent vacuum tube lying near one excited, would glow without being touched. Finger-tips, held near, would emit a brush-like radiance. He thus discovered electrostatic induction, but offered no name or explanation. With delicate ingenuity, he operated one of his small machines inside a vacuum tube, so as to obtain the friction of woolen on amber without losing the vacuum. A vivid luminescence resulted. It was still far from the x-ray, but for the first time in the world, a vacuum tube, the ancestor of all x-ray tubes, was excited by an electrical machine.

A still more surprising forecast is to be related. This may be found in the first American book on electricity, now among the rarest in the collector's library: "'An Epitome of Electricity and Galvanism' By Two Gentlemen of Philadelphia, Printed by Jane Aitkin, No. 71, Philadelphia, 1809." In the historical preface is a paragraph that at once arrests the attention:

"He (Hauksbee) made many experiments to show the extreme subtlety of the electric light, and found out a method of rendering opaque bodies transparent. He lined with sealing-wax more than half the inside of a glass globe, and having exhausted it, put it in motion. On applying his hand to excite it, he saw the shape and figure of all parts of his hand distinctly and perfectly, on the concave superficies of the wax within."

Such a statement of what was apparently an anticipation of Roentgen by a hundred and ninety years, deserved investigation. It was found to be an abstract from the first "History of Electricity" ever written, an almost forgotten volume published in England in 1768, by Joseph Priestley, preacher, chemist, and discoverer of oxygen, whose printed works cover a most extraordinary range of subjects. Regarding the experiments whereby sealing-wax and pitch were rendered transparent, Priestley concludes, "They are really amazing and have not yet been pursued in the manner they deserve."

A recent repetition of those old experiments shows that the appearance to the eye is exactly as Hauksbee described. But, alas, the explanation as given in the light of modern physics is quite different from Hauksbee's, and attributes the transmitted image of the hand to electrostatic induction. However, as we continue on the research trail and later see x-rays produced years before their discovery, we may feel that these experiments of Hauksbee, had they not been forgotten, might have formed a fruitful working hypothesis instead of a prophetic error unmatched in the annals of science. Literally like Aladdin, he had rubbed his lamp and, in the luminous electric of the vacuum, actual genii had appeared, obedient with powers such as Scheherezade in the "Arabian Nights" had not dared to imagine. But many years had yet to pass before a master should come to recognize them and find the magic formula of control.

In 1907 Hauksbee's numerous papers were published in a book dedicated to

Lord John Somers, Lord Chancellor of England, who retired from the presidency of the Royal Society in the year that Hauksbee was elected a Fellow. We catch a glimpse of contemporary England from the fact that Lord Somers was also a patron of "The Spectator" of Addison and Steele. The preface of his book opens with a sentence worthy of Francis Bacon: "The learned world is now generally convinced that instead of amusing themselves with Vain Hypotheses, which seem to differ little from Romances, there is no other way of Improving *Natural Philosophy* but by Demonstrations and Conclusions founded upon Experiments judiciously and accurately made."

It requires only a casual reading of this book to see that while his chief interest was in electricity, Hauksbee's range of investigation makes him an outstanding figure in the experimental physics of his day. He made original inquiries into many subjects, as, for example, the ascent of various fluids in small tubes and very narrow spaces, at a time when there were no terms such as "capillary attraction" or "surface tension" to be substituted for a real explanation. He seems to have been the first to suggest the possibility of liquifying air by pressure. He theorizes: "What kind of liquid would so many Atmospheres of condensed inelastic Air compose? . . . Is it impossible that Air by this means should become a Visible Palpable Fluid; and be the subject to some of the same Management that other Fluids are?"

When the calculations of the Royal Society relative to the refractive indices of compressed air were disputed by the French Academy of Science, Hauksbee was ordered to make instruments of the utmost precision for confirmatory tests. That he executed this commission brilliantly we have his own account, faintly reminiscent of Benvenuto Cellini. He begins: "The Royal Society (whose Glory it is to be as unwilling to deceive as to be deceived) being inform'd that this Experiment was call'd into question by the French Academy, was desirous that it



might be put beyond dispute, by repeated and fully attested Trials. Accordingly I was order'd to make an Instrument for the purpose." And before he has finished we are ready to concede that he was the best maker of scientific instruments in the England of his day and that his experiments settled this dispute for all time, as indeed they did.

Francis Hauksbee was a part of the renaissance of English science and philosophy which reaches its height in the mighty works of Sir Isaac Newton. The Royal Society had become the great protector and repository of the new learning. In the year when Newton became its president (it proved for life), Hauksbee was elected a Fellow and read his first paper before the Society. With this first paper he emerges from utter obscurity and, after a short scientific career of seven years, he disappears as utterly with his last. His name is not listed in the encyclopedias. The histories of the Royal Society are silent except for his scientific contributions. There are no letters, no biography, no portrait, no hint of friend or family, except a single mention of a nephew. In the English Dictionary of National Biography, we find a brief notice of his book only. The date of his birth cannot be given and the date of his death, 1713, is fixed approximately by the posthumous publication of his last paper.

#### IV

We who are born into this present age of electricity may well wonder why electrical development was so long delayed in the world's history. Great civilizations flourished and decayed without bringing comprehension of this all-pervading force. We may turn the pages of history, century after century, until we come to the time of Queen Elizabeth before we find the small beginnings of electrical science. When we see Gilbert, von Guericke and the long line of their successors unaware of the opportunities that surrounded them, we may understand that

they had no idea of what we now naturally expect them to have been looking for. As we trace electrical progress through still more centuries, it seems as if the trail lay through an interminable jungle where concealed facts, like a thousand unseen eyes, watched experimenters struggle along blindfolded and often backwards. Although unsuspected and curiously hidden for the most part, electricity showed one primeval manifestation—lightning. Yet lightning, a terrifying commonplace and the most amazing phenomenon in nature except the rising of the sun, nevertheless had to await Benjamin Franklin for an explanation.

The conception of electricity which prevailed almost to the time of Franklin is hardly credible. s'Gravesande, in his *Natural Philosophy*, a work of astonishing excellence and the recognized authority of its time, still contained in 1747 the following definition: "Electricity is that Property of Bodies by which when they are heated by attrition they attract and repel light bodies at sensible distances."

The sparks resulting from friction were not regarded as electrical but as fire, which was believed to be inherent in all bodies. Conservatism is perhaps a necessary refuge of authority. It is now clear that long before the publication of this edition of s'Gravesande, Gray, in England, had made such a definition of electricity obsolete.

Stephen Gray, seen in historical perspective, loses nothing of his interest and importance. During the period of his discoveries he was a pensioner of the London Charterhouse, a combination of monastery, boys' school, and old men's home. This is the Charterhouse immortalized by Thackeray's "Colonel Newcombe." To become a "poor-brother," one must be over fifty years of age and a member of the Church of England. Such was Gray, who, in old age and poverty, was to gain an honored place among the great investigators who have brought forth knowledge indispensable to the progress of civilization.

He appeared at intervals or sent papers

to the Royal Society. Five of his papers are preserved in the Philosophical Transactions. Gray's humble station was no bar to his entrance into the great Society which early in its career had been taught the democracy of science, curiously enough by a King, George III. The then new Society had rejected a John Graunt on the grounds that he was a tradesman. "His Majesty," with power to recall the charter, curtly disapproved and suggested that if the Society were so fortunate as to find any more tradesmen like Graunt, it should receive them forthwith. The Royal Society, worthy of its name and such traditions, finally bestowed upon Stephen Gray its first Copley Medal.

Gray carried out his experiments under the crudest of conditions, using twine, canes, sealing-wax, fish poles, glassware, wire, tea-kettle, stove poker and other household odds and ends; he acquired also glass tubes, silk thread, blocks of resin, and an old ivory ball. He discovered and established the greatest fact in electrical science, namely, that electricity is a current and will flow over conductors as well as remain a charge on the surface of glass or sulphur, as shown by Hauksbee and von Guericke. Gray's source of electricity was a glass tube or ivory ball excited by friction. He showed that electricity resides on the surfaces of bodies thus electrified; that conductors must be insulated; that insulators are not conductors, and, marvelously, that a charge is induced in a conductor closely parallel to a line carrying a current. In some of his experiments he suspended by cords boys of the Charterhouse, pupils of the "Gray Friars," and electrified them. These experiments were later repeated in France by Dufay and the Abbé Nollet, who were amazed to draw sparks of fire from the human body. Gray continued his researches with unabated zeal until his last illness and, on his death bed, tried to describe to his physician experiments which he saw he could not live to carry out. But he had done his self-imposed

work and pushed ahead the research trail for the next explorer.

Gray, like Hauksbee, is not listed in the encyclopedias. However, Gray's discoveries received unusual public attention during his lifetime because of a generous contemporary and rival in another land. Such is the magic of recognition beyond the boundaries of one's own country.

This rival was Charles Du Fay, who early studied Gray's papers and continued his lines of investigation. Dufay (as the name is usually written) made our research trail into an open path. He was in sharp contrast to Gray—a wealthy Frenchman, highly cultured, noted for wit and tact, a charming companion, and a man of surprising versatility. He had been an officer in the army and a diplomat before he became a member of the French Academy. After learning of Gray's experiments he devoted the remainder of his short life of forty-one years to electricity. It was he who overthrew the distinction between electrics and non-electrics which had obtained since Gilbert's *De Magnete*. He perfected Gray's method of insulation and showed that all bodies thus treated could be electrified. He amplified Gray's observations on the induction of currents. His greatest contribution was his discovery that resinous bodies and glass, when rubbed, yield different kinds of electricity, giving our first knowledge of what Benjamin Franklin rechristened as positive and negative electricity in his single-fluid theory.

Dufay deserves added fame for his generous recognition of Gray's work. It is difficult to recall, in the history of scientific discovery, a finer example of courtesy to a prior investigator than the remarkable acknowledgment, by this brilliant Frenchman, of the work of a "poor brother" of the London Charterhouse. On one occasion when he had prepared for the Royal Society an abstract of his papers before the French Academy, he sent it to the Duke of Richmond to be presented to Mr. Gray, "to whom I acknowledge myself indebted for the discoveries I have

made as well as those I may possibly make hereafter, since it is from his writings that I took the resolution of applying myself to this kind of experiment."

## v

Following Dufay, electrical phenomena passed into a period of remarkable popularity. In Germany, Bose, later professor of physics at Wittenburg, was eager to repeat the French experiments, but having no money for apparatus, he cut off the nozzle of a large retort, in order to obtain a glass tube such as was used by Dufay. One day the globe which remained of the retort reminded him of Hauksbee's globes and rotating machine. He quickly found that no vacuum was needed—only friction on the rapidly revolving globe—to obtain a continuous supply of electricity. Bose's retort happened to be very large, and the quantity of electricity greatly exceeded any hitherto generated. Later, Hansen, of Leipzig, substituted a pad for the hand in making friction, and a truly efficient static machine was finally constructed, capable of unheard-of effects.

Still stronger machines, wire conductors, and insulators enabled experimentors to produce wonders without end, at unbelievable distances. Electrical research was no longer limited to two or three geniuses in a century. Public interest became insatiable. Electrical demonstrations supplanted the theater. Even in the lecture rooms of colleges, the populace crowded the students out of doors. The world was seeing, for the first time, artificial electric sparks, glowing brush discharges from the human body in darkened rooms, the ignition of spirits by fire from a piece of ice or a jet of water, the explosion of gunpowder at a distance, the electrocution of small animals, and innumerable other thrilling demonstrations that now would astonish only children.

Although there were not lacking serious students of this amazing force, yet little progress was made excepting in improved machinery until Dean Von Kleist, of the

Cathedral Camin, invented the Leyden jar so familiar in high school physics.

The vacuum in its relation to the electrical discharge seemed to have been forgotten by these investigators. The rapid development of electrical machinery and the use of conductors had opened new possibilities for the Hauksbee tubes. These opportunities were soon perceived by the Abbé Nollet, a former pupil and companion of Dufay in France, who was to prove a worthy successor to his brilliant friend.

The Abbé Nollet was not an ordained priest but an Abbé of the old régime, a courtier—gay, witty, handsome, a professor in the College of Navarre, and a tutor of the Dauphin. He would appear in his lecture room at Versailles in curled wig, laced-coat, and rapier half concealed by his rich black gown. There were few experiments or startling exhibitions of predecessors or contemporaries that he did not make more startling. He was a man of genius, notwithstanding, and as we follow his work we find ourselves again on the main research trail of the x-ray.

Hauksbee had excited his vacuum tubes by the attrition of his hand or by a little friction machine placed inside of his tubes. Abbé Nollet made his vacuum tubes with sealed-in wires and produced the Hauksbee effects by conductors attached to static machines. Nollet tubes were called, in his own day, "electric eggs"—a truly surprising appellation, for out of them, in all seriousness, hatched x-rays.

Abbé Nollet had actually assembled the essentials for the production of x-rays—the vacuum tube and an outside source of high tension electricity. A little higher vacuum and another wire sealed in the opposite end of his "electric egg"—and the x-ray would have been hatched then and there. But if x-rays had been produced at this time, no one could have known. The x-ray was practically invisible to the eye. That artificial retina, the photographic plate, was not evolved until ninety years later. The fluorescent screen, that step-down transformer of radiations, which could transmute invisible short

waves into longer waves which the eye could perceive, had not been found, although its precursor, the Bologna Stone, had been already the subject of idle investigation in the early part of the Seventeenth Century. So must one discovery wait upon another, and the conjunction of experiments wait upon the inspiration of genius—or a conspiracy of chance.

L'Abbé in many ways showed the scientific spirit. He carried out prolonged experiments to test the action of electricity on seeds, plants, and animals. He made a trip to Italy to investigate the new experiments of Galvani and Volta. He put forth an elaborate theory of electricity and gained a dominant reputation throughout Europe, but he was at his best at Versailles, surrounded by the elegance of the French court in the days of Louis the Sixteenth.

In the midst of this gay, brilliant, and highly sophisticated society, there was one man who held his own in wit, popularity, diplomacy, and scientific discovery. This was Benjamin Franklin. His electrical discoveries topped his already extraordinary reputation and made him easily the most famous man of his day. So manifold were his activities in so many fields that to describe a part of them is to leave a disturbing sense of incompleteness. His single fluid theory of electricity, in which he coined the terms "positive" and "negative" and in which he described electricity as composed of "particles infinitely subtle," has been substantiated by the discovery of the electron, and confirms him as a philosopher of the first rank. Abbé Nollet made an able and sarcastic attack on this theory in defense of his own; but Franklin, with genial wisdom, made no reply, stating that his theory would have to shift for itself. Franklin's name is identified with the electrical investigations of his period. The whole front was moved forward, the atmosphere of experimentation clarified, and the stage set for the next great actor.

## VI

The public, always utilitarian, was soon asking, "What is the use of it all?" Franklin countered, "What is the use of a baby?" While medical quackery was answering the question in its own way, there was another one of those long pauses such as we have seen between Gilbert and von Guericke, or Hauksbee and the Abbé Nollet. It was a period of digestion during which minor experimenters were assimilating former discoveries that mark the general history of electricity rather than our research trail. Then came the genius who was to give the long-deferred answer to the question of electrical utility and, incidentally, to outfit the next explorers on the trail.

A young man of nineteen, an apprentice to a bookbinder, poor, with little education, but with a divine faculty of imagination, heard four lectures by Sir Humphrey Davy. He had already made some primary experiments in chemistry and constructed a static machine. The lectures fired him with the desire "to escape from trade which I thought vicious and selfish and to enter the service of science." Davy had the insight to recognize something unusual in this boy and made him his assistant in the Royal Institution, little dreaming that he was installing his successor. Thus was Michael Faraday, the incomparable experimenter, started on a career that was to alter civilization more profoundly than the wars of Napoleon.

The Royal Institution, where Davy and Faraday carried on their investigations, was founded by an American, Sir Benjamin Thompson, Count Rumford, thus strangely balancing the Smithsonian Institution in Washington, founded by an Englishman. Thompson, born two miles from the birthplace of Franklin, is a remarkable parallel to this other American Benjamin in the fertility and direction of his genius and in that mixture of business wisdom, diplomacy, inventive aptitude, and love of research.



Faraday's discoveries were multiform and again tempt us far afield. But for our purpose, it is sufficient to note his work on electro-magnetic induction of which he was the co-discoverer with Joseph Henry, secretary of the Smithsonian Institution. In the incredibly brief space of three months, Faraday alone had worked out the laws upon which depend, with hardly an exception, all the vast modern electrical industries—power, lighting, traction, telegraphy, and minor applications such as electro-typing and plating. He invented the dynamo and, in principle, with Henry, the first induction coil or transformer which was the general type of apparatus used by Crookes and Roentgen in their experiments, and still is used for the production of x-rays in all the laboratories and hospitals of the world.

It was Faraday's exquisite precision in the measurement of the quantity of electricity required to deposit a certain quantity of silver in the process of electroplating which first demonstrated that electricity existed in quanta or multiples of a unit of either energy or matter. Sir J. J. Thomson, in the Cavendish laboratory, in 1897, showed that the cathode ray in an x-ray tube is a stream of these electric quanta, or units, not of energy but of matter which could be deflected by a magnet. These were the electrons before mentioned, the "particles infinitely subtle" of Franklin, named by Johnston Stoney, weighed and measured by Millikan, and constituting in the aggregate the electric current. Thus did the x-ray lead directly to the discovery of the electron, which is the basis of our understanding of electricity and of the atom.

Much as his discovery stimulated research, it was rather by speculations of a highly theoretical nature that Faraday was destined, after his death, to start another pioneer on the trail of the x-ray. In the early part of his career he delivered a series of lectures on "The General Properties of Matter," and one of these bore the title "On Radiant Matter." He suggested that the luminosity of highly rare-

fied gases in a vacuum tube when excited by electricity was a property of matter in a fourth state. The three states, solid, liquid, and gaseous, were acknowledged realities; why not also a fourth state above the gaseous?

This hypothesis fascinated William Crookes, who, as a teacher of chemistry, was already a scientist of training and experience when he entered upon the line of experimentation which was to lead to the end of the trail. His memorable address before the British Association for the Advancement of Science in 1879 was on "Radiant Matter" and opened with a tribute to Faraday, who had inspired him. The subject was presented with a thoroughness and brilliancy that makes Crookes' papers classics in research.

Crookes used vacuum tubes in many different forms, original designs, containing various terminals and interior devices for demonstrating the properties of "radiant matter." In the long hiatus between the Abbé Nollet and Crookes, vacuum tubes had undergone modification at the hands of Geissler, Plucker, Hittorf, and others. Hauksbee's tubes were without leading-in wires, Nollet's tube had a single wire, and now the German tubes had two wires sealed-in, so that the electric current had to pass through the vacuum to complete the circuit. So ingeniously formed and so beautifully luminescent were the tubes of Heinrich Geissler, a glass blower of Tubingen, that the name "Geissler tubes" came to be a general designation for tubes of low vacuum.

But high vacuum tubes became known as "Crookes tubes." The induction coil supplied a controllable current. Crookes showed that as soon as matter entered into the fourth or "ultra gaseous state," entirely new phenomena were produced. These he studied in nearly every phase: the production of colors, their stratification, the dark spaces, the changes about cathode and anode, and the cathode ray. He showed that this luminous matter radiated in straight lines if the vacuum were

sufficiently high, cast shadows of objects placed within the tubes, could be made to turn a delicate paddle wheel, and even melt refractory metals such as platinum. Within the tubes, diamonds, rubies, and various chemical compounds glowed with striking brilliancy.

Crookes papers were considered as perfect examples of pure science safely remote from possible utility. But pure science has ever been the path to discovery and invention. Crookes had raised his vacuum to the millionth of an atmosphere, which is within the limits of x-ray production. He noted the greenish-yellow color of the glass so familiar to workers with early x-ray tubes, and studied its spectrum. Unconsciously, unknowingly, he was generating x-rays—x-rays in more than sufficient quantity and penetration for practical diagnostic work. To quote from his first lecture "On Radiant Matter":

"This bulb is furnished with a negative pole in the form of a cup. The rays will, therefore, be projected to a focus on a piece of iridio-platinum supported in the center of the tube.

"I first turn on the induction coil slightly so as not to bring out its full power. The focus is now playing on the metal, raising it to white heat. . . I increase the intensity of the spark. The iridio-platinum glows with an almost insupportable brilliancy and at last melts."

This is a perfect description of an x-ray tube in full action, pushed finally to the point of destruction, as many an early roentgenologist was to know to his sorrow. As we turn the pages of Crookes' lectures and read the exhaustive investigation of every possible phenomenon within the tube, we can hardly believe that the next page will not describe what is taking place in the space outside. He found photographic plates out of freshly opened boxes strangely fogged and often blackened. No one could tell why. It is now obvious that this was due to x-rays passing through the paste-board boxes. Crookes tubes, and induction coils to run them, were added to the equipment of high schools and colleges

throughout the world. Many hundreds of trained workers operated and lectured upon Crookes tubes. Tubes varied, but a majority must have produced x-rays, yet no one discovered them.

In one of his lectures Crookes seems knowingly to be dealing with an outside ray. He refers to the "molecular" or "emissive" ray from his tube which can be seen only when a screen is interposed in its path, beyond the tube and compares it to a small beam of light in a dark room which becomes visible only when it strikes upon a cardboard. He does not tell us the composition of his screen. Keen, tireless, resourceful, a genius of the first rank, nevertheless, he remained oblivious to the one most important phase of his life-study—the penetration of opaque bodies by his "emissive ray."

If Crookes had studied Francis Hauksbee he would have gone to the source of the idea and of the term "radiant matter," and would have been reminded of the possibility of the penetration of opaque material by emanations of a vacuum tube made luminous by electricity. Hauksbee says: "Here's a figure transmitted through the most dense and compact part of an opaque Body, with the same facility and advantage to the Eye that it would through those which would seem the most easily pervious to the radiant Matter which is to form the Representation."

The papers of Hauksbee and Crookes lie together in the Philosophical Transactions of the Royal Society, to supplant each other historically and to arouse meditations on the elusive ways of research.

Sir Williams Crookes was the son of a London tailor. He was self-taught for the most part and as a boy experimented in a little laboratory of his own making. He devoured books after the manner of youthful genius. He never attended a university, and, like Franklin, Faraday, and Edison, his originality was never restricted by the educational mould. He became a teacher but never held a professorship. Nevertheless, he received the highest recognition for his work; he was

distinguished as a president of the British Association for the Advancement of Science. Like Sir Isaac Newton, he was made president of the Royal Society and knighted by a queen. Like Gray, he was given a coveted Copley Medal. He received also the Order of Merit, and in 1907 was awarded the Nobel Prize in Chemistry. After all, these are pathetic substitutes for The Great Discovery. It is indeed a poignant tragedy of research that a great experimenter, an Argonaut of science, a worthy successor of his countrymen Gilbert, Hauksbee, Boyle, and Gray, should have been unaware of the Golden Fleece when finally it lay captured, but invisible, in his hands.

Although Crookes unknowingly produced x-rays, he was not the first. In 1785 Morgan, in London, experimented to find if electricity would pass through a perfect vacuum. He formed such a vacuum by boiling the mercury of a Torricellian barometer to expel all the gases. He demonstrated that electricity could not be forced through this vacuum. But in the course of one of the experiments the glass tube cracked so as to admit air very slowly. Morgan then saw a succession of colors beginning with yellowish-green and passing through blue and purple to red. He reported his observations to the Royal Society, suggesting that the degree of a vacuum could be determined by the resulting color of the electrical discharge. After Roentgen's discovery, the identification of the yellow-green shade with x-rays and a repetition of the experiment made it clear that Morgan was the first to produce them. It is also probable that, before the date of Crookes' publication, Julius Plucker and his pupil Hittorf, in Germany, working with high vacua, had unsuspectingly brought forth x-rays. In fact, Roentgen in his original announcement mentions his use of the Hittorf tube. But such were the extent, detail, and skill of Crookes' experiments and such the perfection of his lectures and papers, that the basic work leading to the discovery of the

x-rays remains rightfully associated with his name.

## VII

As we retrace this long trail down the centuries, we find that it has been crossed and recrossed by various thinkers, not a few of great eminence and personal interest, who lingered or took a step or two on the pathway. Such were Sarpi, Cabaues, Descartes, Pascal, Cavendish, and many others, especially since the time of Franklin. Galvani and Volta and the development of the battery, so essential to the early operation of the induction coil, have been passed by. But a few names that necessitate more than passing mention remain to occupy the space of eighteen years that elapsed after Crookes produced x-rays before Roentgen discovered them.

Our trail is unbroken from Faraday to Crookes and then to Roentgen. However, a branch trail of equal importance is seen approaching the x-ray over a wholly different route. This branch was opened by James Clerk Maxwell, who, like Crookes, was inspired by Faraday and his work. Unlike Faraday and Crookes, Maxwell was the scion of an aristocratic family and a finished product of universities. As a professor of physics at Cambridge while still very young, he became particularly noted for mathematical ability. Education had not spoiled him. His sense of humor, outcropping in his whimsical verses, suggests that there are two poles to the mathematical mind, as shown so well by another mathematician, Charles Dodgson, best known as Lewis Carroll the author of "Alice in Wonderland." A certain quality of imagination is needed in creative mathematics as well as in other lines. Certainly it was by a creative genius that Maxwell interpreted Faraday's results in terms of higher mathematics, forming from them one of the most profound theories of any age, the Electromagnetic Theory of Light.

The fascination which this theory exercised over the great von Helmholtz, in Germany, is vividly recounted by Michael

Pupin in his autobiography, "From Immigrant to Inventor." Von Helmholtz extended this theory in his own Dispersion Theory of the Spectrum in which he provided a space for x-rays and for radio waves, specifying their properties, including their power to pass through opaque material, years before either was known or named—a feat of intellect probably never surpassed. It was this theory of von Helmholtz' that led two famous English physicists, Sir Oliver Lodge and Sir J. J. Thomson, to the opinion, only eight months after Roentgen's discovery but over fifteen years before it was experimentally proven, that the x-rays belonged to the short wave end of the light spectrum.

Von Helmholtz was the mathematical discoverer of the x-rays before their physical discovery by Roentgen, just as Leverrier was the mathematical discoverer of Neptune and Lowell of Pluto, before the telescopic demonstration of these planets was accomplished by Galle and Tombough.

Von Helmholtz was more than a theorizer; he set his pupil, Henrich Hertz, to the task of producing some of these electromagnetic waves in his laboratory. This Hertz accomplished in 1888. These waves, henceforth to be known to physicists as Hertzian waves, are the wireless or radio waves which, as few of the millions who use them daily realize, are the outcome of a learned mathematical theory.

Von Helmholtz, great research teacher that he was, had set other students at work in other directions to find other electromagnetic waves. The electrically excited vacuum bulb was suspected to be a possible source of such waves. A glass-blower, Muller, later a famous maker of x-ray tubes, was put to the task of supplying experimental bulbs. One of von Helmholtz' students, Eugen Goldstein, studied the colored stream which was visible between the terminals in these tubes when a current was passing, and named it the cathode ray. This ray, noticed previously by Plucker and Hittorf, was the cathode ray which engaged so much the attention of Sir William Crookes. Some fifteen

years had passed when Philippe Lenard, another student of von Helmholtz and later of Hertz, again took up the investigation of the cathode ray, with results which justified the far-seeing initiative of the great teacher.

Hertz had shown that the cathode rays or stream would pass through a sheet of aluminum placed within the tube. Lenard made a tube with an aluminum window sealed in the glass wall of the bulb where the cathode rays were focussed. The stream passed through this window into air for a distance of about three inches. This distance has been greatly exceeded recently by W. D. Coolidge, who repeated Lenard's experiment, using heavy currents of high voltages, and who showed that the cathode ray is still a fertile subject of research. Lenard identified his cathode ray by the phosphorescence of minerals placed in its path and by the deflection produced by a magnet. He also placed photographic plates in the path, securely enveloped in light-proof holders. The opaque holders were penetrated. Images were obtained of dense bodies placed on the plate-holders. Lenard did not know that the cathode rays, after passing through the aluminum window, were mixed with an abundance of another kind of ray. Unconsciously he was making "x-ray pictures." Was ever a great discovery so often and so closely approached, so long overdue, and hidden by so thin a veil?

#### VIII

While Lenard was still busy with his investigation, looking through the veil darkly, Wilhelm Konrad Roentgen made his historic announcement. December 28, 1895, he handed to the president of the Wurtzburg Physico-medical Society, a paper, "On a New Kind of Ray." Almost overnight it became world-news. Because of Christmas holidays, it was a month later when Roentgen delivered before the Society the deferred address on his "Arbeit." Excepting class lectures, this was his first and last public address on the



x-ray. On March 10, 1897, was published "Further Observations on the Properties of the X-rays," his second and final paper on the subject of this epoch-making discovery.

Roentgen's actual discovery was made November 8, 1895. A false story of the discovery, describing the accidental image of a key developed on a photographic plate, obtained a wide circulation in America, and is still quoted. The true story is given by Sylvanus P. Thompson in his address as president of the newly formed London Roentgen Society in 1897. We are assured that Roentgen had set up his apparatus for the distinct purpose of investigating possible emanations from a Crookes or Hittorf tube. He was acquainted with the work of Lenard but was not at the time using a tube with an aluminum window. He had covered a Crookes tube with black paper and excluded all the light from the room. He had, lying on a table nearby, a piece of cardboard coated with platino-barium-cyanide, known to be sensitively fluorescent to Lenard's rays. He turned on the electric current to excite the tube and saw the coated cardboard brightly luminous. With the precision of a trained investigator he found the tube to be the source of invisible emanations which could penetrate cardboard or a book of a thousand pages or the flesh of the hand.

He did not at first know that this fluorescence was not due to some species of Lenard's cathode rays that were able to pass through the glass wall of the tube as well as an aluminum window. In his original paper, after giving experiments to settle this point, he says: "I therefore come to the conclusion that the x-rays are not identical with the cathode rays but that they are generated by the cathode rays at the glass wall of the discharge apparatus."

From the day of the discovery to the day when he handed in his first communication, he gave himself unremittingly to experiments with this new emanation, often eating and sleeping in his laboratory. His wife, Bertha, was his only con-

fidante. Even his assistant, who pumped his tubes, knew nothing of the discovery until after its publication. Alone he discovered the x-rays and alone he proved that they were different from every other kind of radiation hitherto recognized and described.

Honors were piled upon him. He declined the proffered "von," the sign of nobility. He was unchangeably modest and shrank from public notice. Notwithstanding many alluring invitations from institutions of learning, he held to his professorship at Wurtzburg until, in 1900, the Bavarian Government, which had conferred upon him the "Verdienst Orden" of the Crown, virtually commanded him to accept a call to the University of Munich. In 1909 he received the Nobel Prize. At the height of the World War he returned the honors which he had received from various foreign governments, including the Order of the Italian Crown and the Rumford Medal of the English Royal Society.

Roentgen was descended on his father's side from an ancient Rhenish merchant family. His mother came of good Dutch stock whose forebears had emigrated from Italy in the Seventeenth Century. He was an only child, born in Lennep, a small city on the Rhein, where he passed a happy childhood. He was more fond of the outdoors than of books and later in life delighted in mountain climbing. He was not at first distinguished as a student and was once expelled from his academy after steadfastly refusing to give the names of his associates in a harmless prank. He failed to pass the examinations for admittance to the University. It is apparent that this was due to indifference rather than any lack of ability. Later when he came under the influence of August Kundt, a professor of experimental physics, an enthusiasm and a purpose were aroused that determined his career. His reputation grew with the publication of many research papers. He advanced steadily, attaining one position after another until he was made a professor of physics in the

strict old University of Wurtzburg which once had refused to accept him as a student. Here in later life, in the security and serenity of an academic career, with an established reputation, he accomplished his great "Arbeit," in defiance of those conditions which so often bring on a sterility of genius. Such was his patriotism that, in the extremities of the War, he turned over his worldly possessions to his country. He was childless, the last of his line, and the death of his devoted Bertha left him peculiarly alone. Four years later, in 1923, at the age of seventy-eight, he died of cancer, in great poverty, under the roof of a friend. His final resting place is at Giessen, where as a young professor he spent the happiest years of his life.

One of Roentgen's memorials is the finely executed statue on the Potsdam Bridge, showing him, Jove-like, seated and gazing with brooding eyes at a vacuum tube held in one hand. Many other investigators had gazed long and earnestly on this fateful tube and had carried the torch of research down the centuries—but the secret remained a secret. The eye had to see beyond the tube. The flash of the fluorescent screen had to be answered by a flash of supreme genius. So priceless is the gift of scientific intuition and so difficult the discovery of a new fact, that unconditional admiration is due the man who first recognized these long-hidden rays and who first saw shadows made by invisible light.

#### IX

Our research trail continues until the x-rays have been traced and identified as part of the spectrum. This revelation

did not come for fifteen years after Roentgen's discovery. No one had been able to reflect or refract x-rays and thus prove their relation to light. Finally Professor Max Laue, of Munich, reasoned that if the wave lengths of the rays were sufficiently short, then ordinary mirrors would be to them what a pebbly road-surface would be to ordinary light. He proposed the use of the cleavage plane of a crystal so as to secure rows of atoms which would provide the smoothest surface in nature and the closest possible grating for the production of an x-ray spectrum, if these rays were of the order of visible light. Although the actual experiment was made by Knipping and Friedrich, at Freiburg, the achievement is universally accredited to Laue. A more brilliant example of deductive reasoning is hard to find. The prediction was verified in every particular, the rays were located at the ultra-violet end of the spectrum, and the designation X, an unknown quantity, became henceforth a matter of history. This work with the tiniest of cosmic bodies, the bending of unseen radiations by the unseeable structure of crystals, is indeed a fairy-tale of science in which the real treasure was found to have been hidden all the time in the far end of the rainbow.

We have come to the end of the trail only to find that this is a fresh starting-point for advances in many directions. Thus it must be with every discovery, so long as the human mind thirsts after knowledge. If the future is to repeat the past, then succeeding generations will look back on Millikan and his confrères, not as completing the conquest of that last frontier of the spectrum, the cosmic rays, but as opening a trail to frontiers yet unseen.

## ULCERATIONS OF THE STOMACH AND SMALL INTESTINE FOLLOWING ROENTGEN THERAPY<sup>1</sup>

REPORT OF A FATAL CASE, WITH PERFORATION

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THE possibility of damaging the gastro-intestinal tract by deep roentgen irradiation was first brought out in 1912 by Regaud, Nogier, and Lacassagne.<sup>2</sup> Describing the effects of irradiation in dogs they noted especially gastric atrophy and intestinal ulceration, with and without perforation. Important contributions to this aspect of the problem have been made by Warren and Whipple,<sup>3</sup> and by Martin and Rogers.<sup>4</sup>

Clinical records of ulceration of the gastro-intestinal tract in man following deep x-ray irradiations have been contributed by: Kroemer,<sup>5</sup> Franz,<sup>6</sup> Heck,<sup>7</sup> Fischer,<sup>8</sup> Bécélère,<sup>9</sup> Mathias,<sup>10</sup> Ball,<sup>11</sup> Case and Warthin,<sup>12</sup> and Seigmund.<sup>13</sup>

We desire to place on record the following case of multiple ulcerations of the stomach and bowel which terminated fatally by perforation.

R. B., a salesman, 48 years of age, was admitted to St. Luke's Hospital on March 18, 1929, having been referred by Dr. A. J. Goodwin, of Kankakee, Illinois. It appeared from his history that during the preceding September he had noticed a small tumor mass in the left axilla. This under-

went a slow increase in size until it was removed in November, 1928. It consisted of several lymph nodes, the largest of them measuring about 4 cm. in diameter. On section, they showed the characteristic architecture of Hodgkin's granuloma. The blood Wassermann was fully negative at that time. The blood count was: erythrocytes, 4,020,000, hemoglobin, 90 per cent, and leukocytes, 13,800, with polymorphonuclear neutrophils, 84, large mononuclears, 2, and lymphocytes, 14. There was no complaint of cough, dyspnea, or chest pains, and no development of sensori-motor disturbances. His urine was normal. Except for sciatica five years previous, and a small hydrocele, his past medical history was without incident. Within a few weeks glandular hyperplasia had reappeared about the original site in the left axilla and about January 1, 1929, he began to experience discomfort and pain after eating and was much troubled by accumulation of gas in the stomach. These symptoms grew progressively worse until, at the time of admission, they recurred after each time he took food, depending in severity and duration on the amount eaten. Despite these discomforts, he had a good appetite and continued his normal food habits. The nights were usually fairly comfortable and he was entirely free from pain in the morning. He had never vomited and he did not require cathartics. He had never noticed tarry stools. He had maintained his normal weight and endurance. An x-ray fluoroscopy of the gastro-intestinal tract, using barium, failed to reveal any evidence of gastric or duodenal ulcer. Chest roentgenography failed to reveal any adenopathy that might be due to Hodgkin's disease. There was a good deal of hypertrophic osteo-arthritis involving the dorsal spine.

<sup>1</sup> Read before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

<sup>2</sup> Arch. d'électricité méd., Oct. 10, 1912.

<sup>3</sup> Jour. Exp. Med., 1922, 35, 187.

<sup>4</sup> Am. Jour. Roentgenol. and Rad. Ther., 1924, 2, 280.

<sup>5</sup> Monatschr. f. Geburtsh. u. Gynak., 1917, 46, 292.

<sup>6</sup> Berlin klin. Wehnschr., 1917, 27, 663.

<sup>7</sup> Strahlentherapie, 1920, 798.

<sup>8</sup> Strahlentherapie, 1921-1922, 332.

<sup>9</sup> Presse med., Nov. 23, 1921.

<sup>10</sup> Centralbl. f. allg. Path. u. path. Anat., 1921-1923, 33, 65.

<sup>11</sup> Am. Jour. Roentgenol. and Rad. Ther., 1925, 13, 220.

<sup>12</sup> Am. Jour. Roentgenol. and Rad. Ther., 1924, 12, 27.

<sup>13</sup> Handb. d. Spez. path. Anat. u. Histol., Berlin, 1929, 4, Part 3, 337.

Upon examination a generalized adenopathy became apparent, palpable lymph nodes in the inguinal, axillary, cervical, and supratrochlear regions being present, and deep abdominal palpation revealed a

determine the existence or otherwise of mediastinal gland involvement showed normal root shadows and the posterior mediastinum to be clear. Besides a fair amount of infiltration involving the smaller

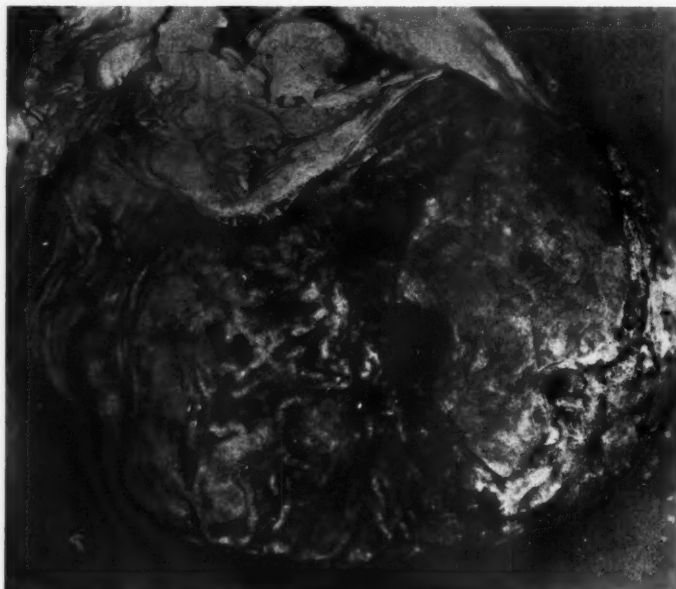


Fig. 1. Photograph illustrating the huge spontaneously perforated ulcer in the cardiac portion of the stomach. Note the small ulcers in the mucosa along the margin of the large lesion.

marked enlargement of the mesentery lymph nodes. The spleen was enlarged to the costal margin. The liver was not palpable. In the mid-epigastrium, from about two inches below the xyphoid to the umbilicus, was a mass about as large as a grapefruit of somewhat nodular form and smooth in consistency, not tender and very slightly movable either to manipulation or on respiration. This was judged to be due to an agglomeration of enlarged glands. The tonsils were atrophic and the mouth showed a chronic gingivitis. The blood count revealed: red cells, 4,360,000; leukocytes, 8,550; hemoglobin, 85 per cent; differential—neutrophils, 78 per cent, eosinophils, 2 per cent, lymphocytes, 20 per cent.

An x-ray examination of the thorax to

bronchi of both lungs and an area of what appeared to be scar tissue in the right lower lobe, the lungs appeared to be free of pathology. The diaphragm was regular on both sides except for a slight flattening on the left.

The patient was given a series of x-ray therapeutic treatments consisting of four exposures on successive days. There was no disagreeable reaction. He left the hospital with condition unchanged.

On April 15, 1929, he was re-examined. His body weight remained unchanged. His abdominal discomforts, which had disappeared for a period, were again in evidence. The spleen could not be felt but the abdominal glands were still palpably enlarged although smaller than formerly. No other adenopathy existed. About this



date a complete barium fluoroscopy was carried out, reported by Dr. Alfred M. Houston as follows:

"Lungs and heart show no roentgen evidence of pathology on screen observation. Esophagus of usual size, position, and contour. The stomach is fishhook in type, medium sized, with usual tone and peristalsis. The wall seems normally flexible and no filling defects in contour noted. The stomach is empty in six hours, with head of the barium meal in cecum. The pylorus functions normally. The caput is large and fills to regular contour under pressure. The second portion of the duodenum is somewhat dilated but shows the usual course. The terminal and transverse portions of the duodenum show considerable dilatation and appear to be firmly fixed across the middle of a tumor mass palpable in the upper abdomen. There is marked 'rocking' of duodenal contents. No definite roentgen evidence of pathology is noted in the rest of the small bowel. The terminal ileum is visualized at six hours. The transverse colon can be moved freely over the abdominal tumor mass. The splenic and descending colons are apparently normal. The impression gained from the examination is that the tumor mass is probably retroperitoneal."

Our patient received a total of 2,180 r units, covering a period of nine months, from March 18 to December 12, 1929. There were nine sessions of therapy, usually consisting of one area to the anterior abdomen and one to the posterior abdomen. At no sitting did we give over 320 r to any one area. On two occasions we gave a total of 640 r through two portals. He received his last x-ray treatment on December 12, 1929, on which date we administered 320 r units.

His blood count January 15 was: red cells, 3,160,000; leukocytes, 4,400; hemoglobin, 65 per cent; neutrophils, 40 per cent; eosinophils, 20 per cent; lymphocytes, 40 per cent. Since his last x-ray treatment, he had felt weak and complained of generalized aching, especially severe across the abdomen, and decline of appetite. The temperature had not been elevated. There were no cutaneous lesions. On February 3 his temperature was 98.8; pulse 78, and the abdomen somewhat tympanitic. The spleen was not demon-



Fig. 2. Photograph illustrating the ulcers in the lining of the small bowel, encircling the lumen excepting a short segment on the antimesenteric side.

strably enlarged. In the right lower quadrant was a firm, irregular mass, easily felt through the thin abdominal wall. It was not tender and gave the impression of hard feces in the cecum.

He was hospitalized February 3, 1930. Under observation, distinct periodicity was apparent in the occurrence of the abdominal pain. It showed immediate increase after eating and lasted from one to three hours. There was a good deal of intestinal flatulence. There were no other symptoms with the exception of a slight

shortness of breath on exertion and a sense of fullness in the epigastrium. There had been very little complaint regarding pain until February 1, three days before admission, although preceding that date, and for a period of about two weeks, there had been present a dull ache on both sides of the abdomen, more especially on the left. It became much more severe on the date named and was punctuated by acute exacerbations, referred to the epigastrium and to the infra-costal region, especially after the taking of food. It was to some little extent influenced by posture, being relieved somewhat by the patient's turning on either side. Abdominal examination demonstrated a mass about 3 cm. below the umbilicus, to the left of the one described. These masses were not freely movable and were not tender to palpation. The liver margin could not be palpated and the spleen was not demonstrably enlarged. It was observed that the patient's rectal temperature showed a slight afternoon elevation. On the fourth day, following admission, without preceding chill, the body temperature suddenly increased to 104.6. From this high peak, there was a gradual decline until the rectal temperature reached normal in about four days.

On February 13 there occurred a sharp chill, with an increase of temperature to 104, and it remained persistently high thereafter until death. Neither physical nor x-ray examination could demonstrate any pathology of the lung.

The patient complained of severe pain in the back about the twelfth dorsal segment, radiating into the upper abdomen. In consequence of this, he had had a poor night's rest. On abdominal examination there was a vague indication of a slight amount of free fluid in the abdomen. Neither the spleen nor the liver was enlarged. The chest was clear. The eosinophil count was 4 per cent.

On February 14 the abdomen appeared swollen and somewhat rigid and there was undoubtedly free fluid in the peritoneal sac. On the preceding day he had had a sharp chill followed by a rise in tempera-

ture. It was apparent that the patient had a general peritonitis. Surgical consultation with Dr. S. W. McArthur was followed by immediate exploratory laparotomy. A mid-line incision was made. On opening the peritoneal cavity, a milky, greenish fluid in considerable quantity was found and the peritoneal surfaces were covered with a good deal of fibrinous exudate. The appendix was isolated and found to be retroperitoneal and retrocecal. It was reddened and swollen. No other definite local pathology being demonstrable, the abdomen was closed with drainage.

The patient died on February 19.

*Necropsy.*—The essential features of the post-mortem examination (Edwin F. Hirsch), which was limited to the trunk, are as follows: There was a recently repaired surgical incised wound in the midline of the abdomen. On the surfaces of the peritoneum, there was a generalized fibrinous exudate. The appendix vermiformis had recently been removed; the amputation stump was tied off and covered with peritoneum so that the fecal material did not escape. The spleen weighed 115 grams. Fibrous adhesions, between the anterior and posterior walls of the lesser peritoneal space, markedly shortened the lateral extent of this space. In exploring these adhesions between the posterior wall of the stomach and the pancreas, an encapsulated perforation of the stomach wall was encountered and from this a quantity of bright red blood escaped. The greater curvature of the moderately distended stomach extended 10.5 cm. below the tip of the xyphoid in the midline; the lesser curvature, 3.5 centimeters. In the fat tissues between the greater curvature of the stomach and the transverse colon, there were several white, flat, opaque lymph nodes as large as 1 cm. in diameter. The distal portion of the transverse colon was bound in the adhesions on the posterior surface of the stomach. The lymph nodes in the root of the mesentery were firm, opaque, white tissues as large as 2 cm. in diameter; the biliary lymph nodes were as large as 2.5 centimeters. The lining of the

thoracic portion of the esophagus was unchanged. The cavum of the stomach contained a large dark red blood clot. On the posterior surface of the cardia was a huge circinate ulcer of the lining that reached to the greater curvature. It extended 9 cm. in the longitudinal axis of the stomach, and 12 cm. in the transverse. The flat black granular floor was depressed 6 mm. below the overhanging and undermined edges. On the greater curvature, just beyond this huge ulcer, was another, a punched-out defect, 2 cm. in diameter, and proximally was a third one almost as large. Along the edges of the large ulcer were several more, much smaller in size. The hilum of the spleen was opposite the proximal margin of the large ulcer. There were no ulcers or other changes in the duodenum. In the lumen of the duodenum was a fluid stained red with blood. The small and large bowels were opened lengthwise along their mesenteric attachment. Much of the jejunum had the usual circular folds, but in the ileum were dark gray and green ulcerations, rough and warty, as wide as 2 cm., and encircling the lumen as much as 5 or 6 centimeters. They were arranged toward the side of the mesenteric attachment, and on the side away from the mesentery was an interval of bowel lining of from 5 to 10 millimeters. The distal ulcer was 90 cm. from the cecum; others were distributed proximally above the first at intervals of from 20, 33, 8, 3, 2.30, and 38 centimeters. The oval Peyer's patches, from 1.5 to 2.5 cm. in diameter, were stippled with black. The lumen of the small bowel contained a large quantity of fluid stained with blood. There were no ulcers or other changes in the lining of the colon and rectum.

There was considerable fibrous tissue between the aorta and the lumbar vertebrae and about the inferior vena cava below the level of the renal vessels. Just above the right renal vein was a soft, gray lymph node 2.4 cm. in diameter. In the fibrous tissues about the left renal vein were small masses of lymph node tissues. The right and left

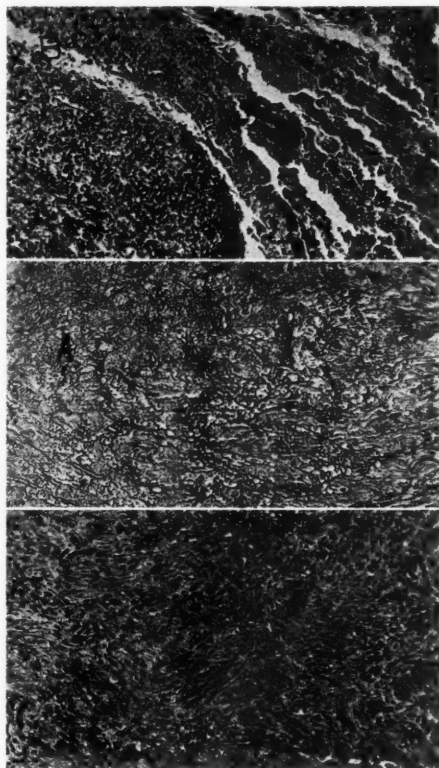


Fig. 3. *Upper.* Photomicrograph illustrating the undermined margin of the large ulcer of the stomach. A fold of gastric mucosa (A) overhangs the edge, and the base (B) is chronic granulation tissues. There is no resemblance of these tissues to those in the lesions of lymphogranulomatosis.

Fig. 4. *Center.* Photomicrograph of the edematous collagenous connective tissues (A) in the submucosa. These changes extended for a considerable distance around the margin of the huge ulcer of the stomach. Comparable changes occur with roentgen-ray burns of the subcutaneous tissues.

Fig. 5. *Lower.* Photomicrograph of the granulation tissues (A) about the ulcers of the small bowel.

groin lymph nodes were not enlarged; the axillary was but moderately enlarged.

Hemolytic streptococci were identified by cultures of the peritoneal exudates. The routine examination of the other tissues of the trunk demonstrated no noteworthy changes.

*Anatomic Diagnosis.*—There were the following findings in the anatomic diagnosis: huge perforated ulcer and multiple small ulcers of the membranous lining of

the stomach; annular cicatricial ulcers (eight in all) of the lining of the small bowel; acute generalized sero-fibrinous peritonitis; bilateral fibrinous pleuritis; huge recent hemorrhage into the lumen of the stomach; recent hemorrhages of the lungs; hyperplasia of the spleen, parabronchial, mesenteric and biliary lymph nodes; marked fatty changes of the liver; cloudy swelling of the myocardium, liver, and kidneys, etc.

*Histology.*—Tissues from the edge of the huge ulcer of the stomach were examined in histologic preparations. The mucosa, tunica propria, and tissues as deep as the muscularis ended abruptly at the edge of the ulcer and formed an overhanging edge. The stomach wall beneath the ulcer and to the subperitoneal fat was cellular chronic granulation and scar tissues of variable thickness, in some places scarcely 1 millimeter. Along the edge toward the lumen was a narrow margin of necrotic tissue and exudate with markedly diminished staining qualities, and in the surface of this was a leukocytic exudate. The cells of the granulation tissues were held in a hyaline stroma of coarse threads, some of which probably were remnants of the original tissues of the wall. These cells were chiefly small lymphocytes and large monocytes; a few were polymorphonuclear leukocytes. Only small bundles of smooth muscle remained. A noteworthy histologic change was the marked widening of the submucosa for a considerable distance about the ulcer margins by edematous hyaline fibrous tissue with very few nuclei. Wide collarettes of dense hyaline fibrous tissue surrounded the large blood vessels in these places.

The ulcers of the small bowel were edematous mucosa, markedly infiltrated with lymphocytes and polymorphonuclear leukocytes. Along the lumen was a margin of necrotic tissue covered with a fibrinous exudate. Much of the lining epithelium had been destroyed and in the crypts between the villi were the basal portions of tubules lined by a columnar epithelium. The muscularis was infiltrated with round cells and polymorphonuclear leukocytes.

The parabronchial lymph nodes had many large mononuclear cells, not a few with carbon pigment, some with brown blood pigment. The stroma was edematous, and in the meshes of the reticulum fibers were lymphocytes, plasma cells, a few neutrophilic and eosinophilic leukocytes, and an occasional small multinucleated giant cell. Narrow collars of hyaline connective tissue surrounded the small blood vessels. There were only slight connective tissue changes in the spleen. Large portions of the left renal lymph node tissues were necrotic. The intact tissues consisted mainly of compact small and large lymphocytes in an edematous reticulum. The pattern of structure in the necrotic portions was faintly retained and where these merged into the non-necrotic portions there was a margin of variable width composed of large mononuclear phagocytes, polymorphonuclear leukocytes, and pyknotic or fragmented cell nuclei. There was a slight granulation tissue reaction.

A periaortic abdominal lymph node had large and small irregular lobed masses of dense hyaline material. Some were acellular coarse masses of collagenous connective tissue, many others had slender crevices with elongated and compressed fibroblastic cells, lymphocytes, or plasma cells. The interstices between the hyaline masses had a cellular fibroblastic stroma with many plasma cells and small lymphocytes. There were no appreciable numbers of eosinophilic or neutrophilic leukocytes. Many of the medium-sized arteries had the usual muscular media, narrow intima, and a broad hyaline fibrous adventitia. Other blood vessels of this caliber had thick hyaline walls and a narrow endothelial lining. Another lymph node nearby had a few hyaline masses and changes comparable only in a general way to those of lymphogranulomatosis.

The visceral changes demonstrated by the post-mortem examination and histologic studies consist, in brief, of the following: a single huge perforated ulcer and multiple smaller ulcers of the stomach;



multiple (8) circumscribed annular ulcers of the small bowel (ileum); necrosis and hyaline scar tissue changes of the perirenal and mesenteric lymph nodes. The gross and microscopic examinations of the parabranchial, biliary, mesenteric, and perirenal lymph nodes disclosed tissue structures that had only the slightest resemblance to lymphogranulomatosis, and the spleen had no indubitable changes of that disease. The evidence of an active lymphogranulomatosis accordingly dwindles to a small quantum.

Considerations directed toward establishing a causal factor for the multiple foci of necrosis take into regard the anatomic conditions of the lesions respectively in the stomach, the small bowel, and the lymph nodes. It is reasonable to believe that the necrosing agent is common for all, and a further basis for this conclusion rests upon similarity of tissue alterations in each.

Although the published reports of gastrointestinal damage by deep roentgen therapy are few, certain ones on record describe conditions comparable to those found in this patient. The indictment of the roentgen therapy as the noxious agent has in support these published reports, although due regard is taken of the many therapeutic treatments given in which no serious damage has been demonstrated, at least by anatomic studies.

It may be proposed, in discussion of the foregoing interpretation of the findings described, that these lesions represent spontaneous ulceration of lymphogranulomatosis tissues in the gastro-intestinal tract. It is well known that no organ of the body is exempt from involvement in lymphogranulomatosis. Cases have been reported showing apparently isolated primary involvement of skin, mamma, kidney, uterus, iris, conjunctiva, tonsil, dura, lung, bone, intestine, and stomach. While the early manifestations are usually glandular these may escape detection because of their obscurity, and the disease process appears to be confined to a single locality such as the intestine or stomach. Stein-

del<sup>14</sup> was the first to describe a case of Hodgkin's disease (lymphogranulomatosis) strictly confined to the stomach. A number of cases, six in all, have appeared in the literature since Steindel's report. These are described and discussed by Singer,<sup>15</sup> who adds a case of his own. All of these cases came to light only after a histologic examination of the material removed at operation. The pre-operative diagnosis had been either peptic ulcer or carcinoma of the stomach. The literature of reported cases indicates that a diagnosis is seldom if ever made until the surgeon makes an exploratory laparotomy and even then the correct diagnosis is determined by the pathologist.

A. Grevillius<sup>16</sup> describes two forms of lymphogranulomatous involvement occurring in the gastro-intestinal tract. The first resembles tuberculous ulceration with a necrotic surface and elevated edges, these ulcers having a tendency to spread. They do not cause any change in the mesentery glands. The other kind shows limited tumor formation based on a granulation infiltration emanating from the submucosa and built up of fibroblasts, plasma cells, Sternberg giant cells, eosinophils, and lymphoid cells. These tumors indurate and indent the wall of the stomach or gut involving the mesenteric lymph nodes, and give a typical picture of lymphogranuloma.

It is conceivable that if the gastro-intestinal wall be infiltrated and ulceration is pending or has developed, irradiation might have the effect of causing necrosis or hastening the process of softening in such radiosensitive tissue so that the effect of x-ray might be to increase and extend the ulcerative process. On theoretical grounds it may be assumed that this is more apt to happen in intestinal lesions than in gastric. Ivy, McCarthy, and Orndoff<sup>17</sup> apparently proved that the bowel mucosa

<sup>14</sup> Arch. f. klin. Chir., April, 1924, 130, 110.

<sup>15</sup> Arch. Surg., 1931, 22, 1001.

<sup>16</sup> Lympho-granulomatosis i Tarm-Kanalerna Svenska Läkartidningen, 1931, 28, 1105.

<sup>17</sup> Jour. Am. Med. Assn., 83, 1977.

is approximately twice as sensitive to x-ray as the mucosa of the fundal portion of the stomach. As compared with the normal skin, experimental evidence seems to indicate that the normal stomach is twice as resistant to the harmful effects of radiation. The question arises whether or not extensive ulceration of the mucosa of the normal stomach could be produced by any method of x-ray therapeutic cross-fire without concurrent extensive injury to the skin and subcutaneous tissues.

It is well known that most glandular conditions are quite radiosensitive and it might not be unreasonable to believe that lymphogranulomatous infiltration in the stomach or bowel might break down following irradiation. Granting this possibility, the fact remains that many hundreds of patients with Hodgkin's disease have been treated over the abdomen with considerably larger doses than the case herewith reported without serious results following. Over a period of years of treating a great many patients for all types of deep-seated lesions we have never before seen a perforation of a hollow viscus occur. We have given very large doses to patients affected with abdominal Hodgkin's disease with no untoward results. In one such case a total of 9,270 r was given covering a period of three years, and except for a diarrhea which was easily controlled no unfavorable symptoms developed. Another patient who had Hodgkin's disease with abdominal adenopathy was treated still more extensively over a period of three years, so that the skin was very dark and scaly and a marked hypoplastic anemia supervened requiring many transfusions, yet there were no gastro-intestinal symptoms of importance and at autopsy no ulcerations of the stomach or bowel were found. Although clinical considerations do not encourage the belief that x-ray necrosis of deep-seated organs can be in any degree common, the fact that they may occur is established by experimental research on animals and by the few apparently au-

thentic cases reported in the literature. The following considerations lead us to the conclusion that the case herewith reported may constitute such an instance:

(1) The dearth of gross and histologic characteristics of gastric lymphogranulomatosis, especially the absence of a marked thickening of the stomach wall.

(2) The huge extent of the large ulcer and the multiple smaller ulcers.

(3) The undermined character of the ulcer margins.

(4) The marked edema and hyaline changes of the submucosa without appreciable cellular exudates.

(5) The perivascular fibrous changes.

The most careful scrutiny of section from the concomitant multiple ulcers of the small bowel failed to reveal the presence of indubitable lymphogranulomatosis tissues. The entire absence of hyperplastic changes in the agminated follicles of lymphoid tissue (Peyer's patches), and also the lack of any thickening of the bowel wall away from the immediate vicinity of the ulcers, together with the absence of hyperplasia of regional mesenteric lymph nodes, are facts that appear to possess special significance.

#### SUMMARY

Tissue necrosis resulting in ulcerations of the hollow viscera may follow deep roentgen therapy applied to the abdominal region. Such effects have been produced experimentally in dogs, and in a few instances have been recorded in the literature as occurring clinically in man. There is herewith reported with clinical and pathologic detail a case of multiple ulcerations of the stomach and small bowel following deep x-ray irradiation. Death resulted from perforation of a huge ulceration on the posterior wall of the stomach.

We gratefully acknowledge the very helpful co-operation of Dr. Edwin F. Hirsch, pathologist, St. Luke's Hospital, Chicago.

## THE RESULTS OF POST-OPERATIVE X-RAY THERAPY IN CARCINOMA OF THE OVARY

A SERIES OF TWENTY-TWO CASES<sup>1</sup>

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From the Gynecologic Service of Dr. Brooke M. Anspach and the X-ray Service of Dr. Willis F. Manges, Jefferson Medical College Hospital

**D**URING the past several years numerous reports have appeared in the literature concerning the efficacy of roentgen therapy in the treatment of carcinoma of the ovary. Beginning with von Franque (1), who, in 1912, reported temporary improvement in a girl of 16 with ovarian cancer with metastasis, many authors have reported series, the most recent having been reported by Wintz (2). An accurate comparison of results reported by the different observers is impossible because of a lack of uniformity in the listing of data which influence response to any form of cancer therapy. We believe the following facts should always be recorded: the histologic diagnosis, grade of malignancy, degree of operability, and the radiation factors. Of these, the first three can always be grouped in patients treated post-operatively. Comparison of the radiation factors may not be possible in a small series of patients because of the varying clinical response and post-operative course. It may be impossible, because of the patient's condition, to give the maximum amount of radiation deemed necessary, or the patient may be removed from the hospital before adequate radiation has been given. However, the factors employed should be recorded so that statistics suitable for analysis and comparison may be accumulated.

This study is based on the results obtained in a series of patients, 22 in number, who were treated on the gynecologic service of Professor Brooke M. Anspach and the x-ray service of Professor Willis F. Manges at the Jefferson Hospital between 1924 and 1933.

<sup>1</sup> Presented by title before the American Congress of Radiology, Chicago, September, 1933.

### HISTOLOGIC DIAGNOSIS

All patients were operated upon and the diagnosis proved by histologic examination of tissue removed. The following histologic types were diagnosed: adenocarcinoma, four cases; papillary adenocarcinoma, three cases; papillary cystadenocarcinoma, fourteen cases; granulosa-cell carcinoma, one case. The first two types occurred as solid or semi-solid tumors of moderate size. The papillary cystadenocarcinomas were usually large serous or pseudomucinous cysts, in which carcinoma had developed. The single granulosa-cell carcinoma was found in a moderately large tumor with multiple cystic cavities.

### GRADE OF MALIGNANCY

Following the suggestion of H. C. Taylor, Jr., the cases have been divided into three histologic grades of malignancy. The grading of each tissue was done by one of us (J. B. M.) with the assistance of Dr. Baxter L. Crawford, Pathologist to the Jefferson Hospital, who had made most of the original histologic studies. The grading was based upon the degree of anaplasia as indicated by the extent of cell differentiation, variation in size and shape of the cells, and nuclear changes. Each tumor was graded on the basis of the histologic picture alone, no consideration was given in any case to the clinical course.

Low Grade Malignancy, or Grade I, includes those tumors in which well differentiated columnar epithelium lined the glands and cysts, the adult structure being maintained throughout except in occasional areas where the cells infiltrated the stroma

or formed numerous layers within the glands.

Intermediate Grade Malignancy, or Grade II, includes those tumors in which the columnar epithelium was not so well differentiated; the individual cells presenting variations in size and shape, and moderate nuclear changes, with more extensive infiltration and the frequent formation of solid areas. Glandular and papillary structures were poorly developed and distorted.

High Grade Malignancy, or Grade III, includes those tumors in which undifferentiated epithelial cells with marked nuclear changes developed in strands or solid areas. There was little evidence of glandular or papillary structure.

#### CLINICAL CLASSIFICATION

Once a tumor has been definitely diagnosed as carcinoma, the extent of the growth is the important clinical factor influencing the prognosis. Recent authors have taken cognizance of this and classified their cases so as to differentiate between early, far advanced, and hopeless cases. Keene, Pancoast, and Pendergrass (3) considered two groups: Group I consisted of widespread carcinoma in which only a laparotomy could be done; Group II included all cases in which a complete or partial operation was possible. Ford (4) reported results in three clinical groups, unilateral, bilateral, and inoperable. Heyman (5) studied the cases treated at the Radiumhemmet as radically operable, incompletely operable, recurrent, and inoperable. Others have used somewhat similar classifications.

We have adopted the following clinical classification, based upon Schmitz's method of classifying carcinoma of the cervix.

*Group I.*—Ovarian carcinoma without extension or involvement of surrounding or adjacent parts; completely operable. This group consists of unilateral ovarian tumors which are not adherent.

*Group II.*—Ovarian carcinoma with extension or involvement of surrounding or

adjacent parts; completely operable. In this group are placed completely removable bilateral carcinomas, completely removable carcinomas which are adherent, completely removable carcinomas with extension, and Group I cysts ruptured during operation.

*Group III.*—Ovarian carcinoma with extension or involvement of surrounding or adjacent parts; incompletely operable. This group includes all cases in which a partial operation can be done.

*Group IV.*—Ovarian carcinoma with extension or involvement of surrounding or adjacent parts or with metastasis at a distance; inoperable cases in which only a laparotomy and biopsy can be done.

*Group V.*—Ovarian carcinoma, recurrent; inoperable. The terminal stage of all except those cured.

#### IRRADIATION

Irradiation was usually begun from two to four weeks after operation, two methods being used. Prior to August, 1927, massive doses were given in a single sitting, at right-angles to one of three or four pelvic ports. The amount given was that which the skin would tolerate, and the entire course was completed in three or four days. The factors were 3 milliamperes at 170 to 200 kilovolts, filtered through 0.5 millimeter of copper and 1.0 millimeter of aluminum, at 50 centimeters skin-target distance, through ports 16, 19, or 20 centimeters square. An erythema was obtained with 270 milliamperes-minutes of treatment.

After August, 1927, treatment was given after the saturation method of Pfahler (6). Usually four ports were used, though occasionally, in thin persons, only three. The patients were measured and a diagram of the pelvis made by the procedures devised by Weatherwax (7) employing Desjardins' (8) charts. Effective depth dosage was measured in international roentgens and a graphic chart kept to show from day to day the amount of radiation received. All patients after January, 1925, received treatment with the following fac-



tors: 20 or 30 milliamperes, 175 to 200 kilovolts, filtered through 0.5 millimeter of copper and 1.0 millimeter of aluminum at 50 centimeters skin-target distance, through ports 16, 19, or 20 centimeters square. The central ray was directed obliquely into the pelvis. The erythema value from January, 1925, to August, 1930, was 970 r, and since August, 1930, has been 800 r; in terms of milliampereminutes the erythema ranged from 320 to 610 milliampereminutes as determined by the efficiency of the tubes employed and the voltage at which they could be operated.

In all instances an effort was made to give the maximum amount of radiation which the skin, pelvic structures, and general condition of the patient would permit. No attention was paid to the histologic type of the tumor, its grade of malignancy, or degree of operability in determining the amount to be administered, because experience with tumors in other areas had shown that these factors could not be used as criteria for the determination of the amount of radiation required.

Patients were treated on alternate days. Each day treatment was given, enough x-ray was administered through each of the four pelvic ports, so that at the end of four weeks the effective depth dose was from 1,600 to 2,000 r. The general condition of the patient sometimes would not permit this. In stout patients these doses could not always be delivered into the depths because of the danger of damaging the skin. Slender patients permitted of the ready administration of the maximum depth dose.

Radium has been used in association with roentgen irradiation in treatment of these tumors. This is notably true of the patients reported from the Radiumhemmet by Heyman (9 and 10) and by Ford from the Mayo Clinic (4). Radium was not used routinely by us, only three patients in the series having received radium applications; in two, 2,400 milligram-hours were applied through the intra-uterine route, and in the other the radium was applied directly through the abdominal inci-

sion into the tumor mass. It is obviously impossible to draw conclusions from these three patients.

Diarrhea was not uncommon; it was not often accompanied by other symptoms. Abdominal pain or tenderness were only rarely associated with irritability of the bowel developing during irradiation. The diarrhea usually disappeared promptly on cessation of the treatment; in fact, it often stopped if treatment were postponed for one day. While diarrhea as evidence of colitis should be taken into account, it is not an indication for stopping treatment. It cannot be doubted that it is due to irradiation, because it is seen most frequently in thin persons who receive the greatest depth doses.

#### RESULTS

*Histologic Type of Tumor.*—The papillary cystadenocarcinoma was the type most frequently encountered. Of the 22 patients, 14 had this variety, nine were serous, and five pseudomucinous. Seven are alive, six dead, and one untraced. Four of the living had serous tumors and three had pseudomucinous. Four patients with serous tumors and two with pseudomucinous died; the one untraced patient had a pseudomucinous growth.

Four of the five patients living for more than five years had papillary cystadenocarcinoma; three were of Grade I malignancy, the other of Grade III. These patients represent 80 per cent of the five-year cures.

Adenocarcinoma was the next most frequent, four patients having this type and they are all dead. Three of them had incompletely operable tumors, two of Grade II malignancy, and one of Grade III. One adenocarcinoma of Grade II malignancy was wholly inoperable.

Papillary adenocarcinoma was encountered in three patients; one with an incompletely operable Grade III tumor is alive almost two years after operation, with part of the tumor still present. Two patients with this variety are dead. Both had wholly inoperable tumors; one with a

Grade III tumor died three months after operation, the other, with a Grade II tumor, died one year post-operatively.

The one patient with a granulosa-cell carcinoma is the fifth in the group of patients cured for five years. This tumor was of Grade I malignancy.

*Grade of Malignancy.*—Tumors of Grade I malignancy were the most frequently encountered. Of ten cases of this Grade, seven are alive, two have died, and one is

untraced. The average duration of life to date in those who have survived is 38 months; of the two who died the average duration was 6.5 months.

Five patients, all of whom have died, had tumors of Grade II malignancy. Three of them, incompletely operable, had an average post-operative duration of 14 months; in two, with wholly inoperable tumors, the duration of life averaged slightly less than five months.

TABLE I.—COMPLETELY OPERABLE GROWTHS, WITHOUT EXTENSION

Patient No.	Age	Type <sup>2</sup>	Grade <sup>3</sup>	Courses	Total Irradiation		Result
					Skin r	Depth r	
1	T. M.	PCA	I	Oct. 10–Oct. 25, 1928	1,740		Untraced
2	E. L.	PCA	I	July 17–July 24, 1929	1,740	2,280	Living and well, 4 yrs., 6 mos., post-operatively
3	T. C.	PCA	I	Nov. 29–Dec. 23, 1929	2,000	2,800	Died, 1 yr., post-operatively
4	C. P.	PCA	I	Sept. 29–Oct. 21, 1931	1,200	1,680	Died, 1 mo., post-operative ulcerative colitis
5	A. M.	PCA	I	Oct. 10–Nov. 14, 1931	1,360	1,360	Living and well, 2 yrs., 2 mos., post-operatively

<sup>2</sup> PCA = Papillary cystadenocarcinoma.

<sup>3</sup> I = Low grade malignancy.

TABLE II.—COMPLETELY OPERABLE GROWTHS, WITH EXTENSION

Patient No.	Age	Type <sup>4</sup>	Grade <sup>5</sup>	Courses	Total Irradiation		Result
					Skin r	Depth r	
6	H. R.	PCA	III	June 26–June 30, 1926	1,280	1,280	Living and well, 7 yrs., 5 mos., post-operatively
7	M. P.	PCA	I	Aug. 4–Aug. 12, 1927	1,350	1,350	Living and well, 6 yrs., 5 mos., post-operatively
8	M. A.	PCA	I	Aug. 16–Aug. 26, 1927	1,740	2,440	Living and well, 6 yrs., 6 mos., post-operatively

<sup>4</sup> PCA = Papillary cystadenocarcinoma.

<sup>5</sup> I = Low grade malignancy; III = High grade malignancy.

TABLE III.—INCOMPLETELY OPERABLE GROWTHS, WITH EXTENSION

Patient No.	Age	Type <sup>6</sup>	Grade <sup>7</sup>	Courses	Total Irradiation		Result
					Skin r	Depth r	
9	M. Y.	PCA	I	Jan. 29–Feb. 2, 1924	1,450	1,300	Living and well, 10 yrs., post-operatively
10	F. C.	GCC	I	June 13–Aug. 9, 1932	1,040	940	Living, 7 yrs., 1 mo., post-operatively
				Dec. 7 to Dec. 16, 1926	1,840	1,840	
				May 5–May 13, 1927	1,840	1,840	
				April 14–May 12, 1931	1,480	1,480	
11	E. F.	PA	III	Feb. 21–March 2, 1932	1,200	1,200	Died, 1 yr., 6 mos., post-operatively
				Jan. 28–April 16, 1928	1,840	2,300	
12	L. C.	AC	II	Nov. 12–Nov. 25, 1929	730	900	Died, 3 yrs., 8 mos.
				Jan. 9–Jan. 22, 1930	2,000	1,800	
13	M. D.	PCA	I	May 26–June 20, 1930	2,200	2,000	Living, 3 yrs., 10 mos., post-operatively
				March 1–March 26, 1930	2,300	2,100	
14	M. M.	PCA	II	Jan. 25–Feb. 17, 1933	900	810	Died, 2 mos., post-operatively
				Feb. 5–Feb. 11, 1931	480	480	
15	J. A.	AC	III	Jan. 7–Feb. 3, 1932	1,440	1,440	Died, 4 mos.
16	M. H.	PCA	II	Jan. 21–Feb. 12, 1932	960	1,350	Died, 3 mos.
17	A. M.	PA	III	Feb. 18–March 11, 1932	1,040	1,250	Living, 1 yr., 10 mos.

<sup>6</sup> AC = Adenocarcinoma; PA = Papillary adenocarcinoma; PCA = Papillary cystadenocarcinoma; GCC = Granulosa-cell carcinoma.

<sup>7</sup> I = Low grade malignancy; II = Medium grade malignancy; III = High grade malignancy.

Of the seven patients with Grade III tumors, six are dead and one is living for more than six years; in the latter, the tumor was completely operable. Three of those who died had incompletely operable tumors, and in three the tumors were wholly inoperable.

*Degree of Operability.*—Five patients had completely operable tumors (Table I), all large cysts of low grade malignancy. Two patients with a pseudomucinous type of cyst are alive, one four years and six months, the other two years and two months post-operatively. Two with serous tumors died, both in less than one year. One patient with a pseudomucinous tumor is untraced.

Three patients with completely operable tumors with extension (Table II) are alive more than six years after operation, all of them had papillary cystadenocarcinoma, one with a serous tumor of Grade III malignancy, two with Grade I tumors, one of which was serous and the other pseudomucinous.

Nine patients had only partially removable tumors (Table III). Four of them are alive: in three, the tumor was Grade I; in two, serous papillarycystadenocarcinoma, and in the third, a granulosa-cell tumor. The fourth patient in this

group had a Grade III papillary adenocarcinoma. Five patients are dead—in three the tumor was Grade II, in two Grade III.

Five patients with wholly inoperable tumors are dead (Table IV), all in less than one year. Two were of Grade II and three of Grade III malignancy. One patient had an adenocarcinoma, two had papillary adenocarcinoma, and two had papillary cystadenocarcinoma of the serous type.

*Amount of Irradiation* (Table V).—It is difficult to compare the amount of radiation administered to the various patients, first, because of the smallness of the series, and secondly, because of the great variation in their clinical conditions. In some, the disease was so far advanced that death occurred shortly after operation. In others, the course outlined was not completed because of some intervening difficulty. Records have been kept of the radiation given and outlined in terms of r units (Table V). In two, the depth dose was not known; one of these patients died and the other is untraced. Of the nine surviving patients, four received from 100 to 1,500 r, three from 200 to 2,500 r, and two, more than 2,500 r. Of the eleven who are dead and in whom the dose was

TABLE IV.—INOPERABLE GROWTHS, WITH EXTENSION

Patient No.	Age	Type <sup>a</sup>	Grade <sup>a</sup>	Courses	Total Irradiation		Result
					Skin r	Depth r	
18 B. S.	42	PCA	III	Feb. 6–Feb. 10, 1924	800		Died, 4 mos., post-operatively
19 N. C.	46	AC	II	Aug. 9–Aug. 15, 1927	450	540	Died, 3 mos., post-operatively
20 M. L.	54	PA	III	Aug. 25–Sept. 17, 1927	1,550	930	Died, 3 mos., post-operatively
21 A. S.	38	PA	II	July 10–Aug. 1, 1928	1,840	1,840	Died, 1 yr., post-operatively
22 H. F.	35	PCA	III	Nov. 30–Dec. 19, 1928	1,160	1,600	Died, 7 mos., post-operatively

<sup>a</sup> AC = Adenocarcinoma; PA = Papillary adenocarcinoma; PCA = Papillary cystadenocarcinoma.

<sup>b</sup> I = Low grade malignancy; II = Medium grade malignancy; III = High grade malignancy.

TABLE V.—ROENTGEN THERAPY IN CARCINOMA OF THE OVARY: AMOUNT OF IRRADIATION, DEPTH DOSE, r UNITS

	Living					Dead					Untraced	
	1,000–1,500 r	1,500–2,000 r	2,000–2,500 r	2,500 r plus	Less than 500 r	500–1,000 r	1,000–1,500 r	1,500–2,000 r	2,000–2,500 r	2,500 r plus	Amount unknown	Amount unknown
Group 1	1		1					1		1		1
Group 2	2		1									
Group 3	1		1	2	1		2			2	1	
Group 4					1	1		2				
Total	4		3	2	2	1	2	3		3	1	1

known, two received less than 500 r; both of these patients and one who received less than 1,000 r had incompletely operable tumors. Two patients received from 1,500 to 2,000 r and three, more than 2,500 r.

Study of these figures indicates again that the degree of operability and the degree of malignancy are the important factors in determining the response of the patient to irradiation, because, regardless of the amount of roentgen therapy given, all but one patient with Grade III malignancy are dead.

#### CONCLUSIONS

1. It is important in reporting the results of the treatment of cancer by any method that the histologic diagnosis, grade of malignancy, and degree of operability be recorded and that, when radiation has been employed, the physical factors of the radiation dosage be included.

2. In this series of 22 patients, 14 had papillary cystadenocarcinoma (nine serous and five pseudomucinous), four had adenocarcinoma, three had papillary adenocarcinoma, and one patient had a granulosa-cell carcinoma.

3. Of 10 patients with tumors of Grade I, or low grade, malignancy, seven are alive, two dead, and one is untraced. Of

five with Grade II, or intermediate grade, malignancy, all are dead. Of seven with Grade III, or high grade, malignancy, six are dead and one is living for more than six years.

4. The hopefulness of prognosis is proportional to the grade of malignancy.

5. The more completely operable the tumor the better the prognosis.

6. Palliation of symptoms was frequently noted in these patients, lessening of pain and recession of edema, and while the series is too small to permit of accurate evaluation of the results of irradiation it is apparent that irradiation prolonged the life of many of them.

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# RADIOLOGY AND THE RADIOLOGIST<sup>1</sup>

By EDWARD H. SKINNER, M.D., *Kansas City, Missouri*

WHEN this title was presented to the Program Committee in the early part of this year, there was an honest purpose of contributing to the development of public and professional opinion upon the qualification of specialists in radiology. Another idea contributed to the increasing tendency of hospital executives to absorb the functions and perquisites of the radiologist and to make technical x-ray procedures paramount. It seems that we no sooner succeeded in squelching commercial x-ray laboratories than another more highly organized group of modern business executives began placing obstacles in the pathway of radiologic progress. Surely radiology has had a stormy career but it requires far better pilots to guide ships through stormy weather than over calm seas. Evidently we have had some wise pilots in our midst and they have endowed the rest of us with some professional courage.

Certain events of prime importance to radiology occurred this spring and summer. One was an informal demand by certain leaders in oncology upon the officers of American radiologic societies for a more satisfactory qualification of radiologists. Another was the action of the House of Delegates of the American Medical Association in the resolution to the Council on Medical Education upon the qualification of specialists, not only in radiology but in those specialties which do not as yet enjoy such autonomous institutions. Ophthalmology, Oto-rhino-laryngology, and Obstetrics and Gynecology now enjoy reliable Boards that have not as yet indulged in the American trait of bigger and better elephants.

These two events have even been woven into the fabric of radiology during the

days of this Congress of Radiology. Realizing that this was about to happen, I attempted to withdraw my title but the Chairman of the Program Committee insisted that I proceed. Undoubtedly, his idea was to provide this interlude between scientific papers with Pariseau's ascent into the realms of literary heroes and my descent to practical modes and manners.

There are so many trends in radiologic practice that it is increasingly difficult to pick out particular points.

The luck and charm of early roentgen effort, the rule of thumb, and almost the art of procedures have given way to the mechanical and electrical efficiency of modern roentgen apparatus. Likewise the efficiency methods and the research proclivities of the modern medical student have been applied to radiology, especially in the post-war period, much to its advantage. The pecuniary rewards of early radiologists have been jealously regarded by many who may have other ideals than those of Osler as a basis of their medical activities.

The glory of the pioneer radiologist has been invaded by the astuteness and the chiseling of a more modern and observing medical mentality. The freedom of the pioneer is disturbed by the efficiency demanded in hospital management and the time dishonored game of fee-splitting has been glorified into division of fees by the hospital octopus.

Radiology is a service department in diagnostics and an autonomous field in therapy. Service becomes common when it becomes indispensable. The mutual benefit of that service rests upon intelligent co-operation and sympathetic understanding of the needs of the general practitioner or specialist who seeks radiologic service. The scope of radiology is

<sup>1</sup> Presented before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

broadening rapidly, and it is difficult for many to keep abreast of the accessions to its special knowledge.

The primary x-ray field was merely the delineation of topographical variations in tissue densities, and this is a large field. The introduction of opaque media into the hollow viscus, the injection of contrast air, and the production of artificial densities by intravenous chemical compounds have permitted radiology to invade fields almost beyond the realm of physiologic and anatomic imagination. The radiologist seems to spread his tennacles of diagnostic and therapeutic interest into and about the most intimate problems of every specialty. It affords a refinement never conceivable by the wildest hopes of early radiologists.

The x-ray examination of to-day with its multitude of refinements provides a definite answer to many special clinical questions and affords a comfortable corroboration of most clinical observations. The x-ray examination has progressed until the radiologist is no longer satisfied to report upon suspicious shadows; it is no longer a simple photographic technic; it is not merely the taking of films, followed by the dictated report. The x-ray examination is a systematic, painstaking procedure which uses every possibility of shadow value, properly correlated with the clinical history and social career of the patient. The x-ray examination is really a clinical examination with method, mechanics, and manifest artistry.

Radiotherapy provides an entirely different but closely associated field of medical practice. The roentgen examination, while venturing deep into clinical diagnosis, does not carry the essential responsibilities that radiotherapy forces upon the radiologist. The cancer problem looms large here. While the determination of the therapeutic procedure in the given case is a matter of co-operative examination by the surgeon, radiologist, and pathologist, if the therapy is radiologic the responsibility automatically becomes radiologic also. The radiologist has absorbed this

responsibility to an extraordinary degree in the few years that have just passed and the future may secure the gradual absorption of all non-surgical cancer therapy into the field of radiology. Radiologists seem to welcome this responsibility even though the field of oncology may not seem to present such alluring possibilities. This field of radiologic therapeutics, both roentgen and radium therapy, carries a dignity and responsibility that cannot be assailed or absorbed by technician or tyro. The ultimate results of radiologic therapy depend upon the painstaking, thoughtful application of physical and optical laws of radiant energy based upon judgment, backed by experience, and warranted by co-operative authority.

The radiologist must be granted a consultant's status. His reports must be based upon the shadow values of his x-ray examinations and their integration with the clinical career of the patient. There used to be an attitude of competition between clinical diagnosis and roentgen diagnosis. Now this seems childish and foolish. Conferences with the clinician in the roentgen laboratory serve to amplify the shadow values and bring harmony and satisfaction. Without clinical conferences and without the clinical aspects available, the radiologist is inclined to be dogmatic in his reports. This leads to embarrassing misunderstandings. It is a well-known fact and frequently expressed that there may be too much dependence upon the roentgen examination. It is used by internes and even worthy practitioners as a short-cut to diagnosis. Especially is this true in fractures, gastrointestinal and pulmonary cases. It is a great compliment to radiology, but it should not be encouraged at the sacrifice of clinical acumen. It is an injustice to the patient, equally as reprehensible as any failure to demand radiologic consultation when indicated.

The demand that the radiologist be considered a consultant carries responsibilities. The consulting radiologist must have gone through a period of training, acquired

sufficient experience in interpretation, learned the technical requirements of radiologic science, and be possessed of the art of medicine. The radiologist should be a physician practising radiology. The possession of apparatus does not confer the degree of diagnostic ability. The specialist by assertion is quite another individual from the specialist by qualification.

There has been a tendency among many strong, well-qualified clinicians to install x-ray apparatus in their own offices. This was especially noticeable during the late, but departed, prosperous years. It was encouraged by manufacturers of roentgen apparatus. There may have been some jealousy or pique at the number and amount of cases referred to radiologists. There may have been some hope of salvaging some of the profits. Patients are trusting souls, and the convenience of the examination in the clinician's office may have obscured their appreciation of the examination's completeness and values. The glamour and the magic of x-ray ex-

aminations serve to mystify the confiding patient and lull him into a false sense of diagnostic security. There is no doubt that x-ray examinations have been oversold to potential patients and consultation radiology undersold to the profession.

There is a tendency to discontinue this inadequate roentgen examination in the clinician's offices. The overhead of thorough technical x-ray procedures is now impractical under depression stress and strain. The careful clinician is finding that this method of practice is not giving him the results hoped for. Principally, the public is demanding x-ray examinations by radiologists because of their completeness and because the costs of good examinations are identical.

It behooves us, therefore, to subscribe to the programs which may emanate from this congress for the qualification of specialists in radiology. We must attach our influence to the general program of the American Medical Association for the qualification of specialists in all fields.

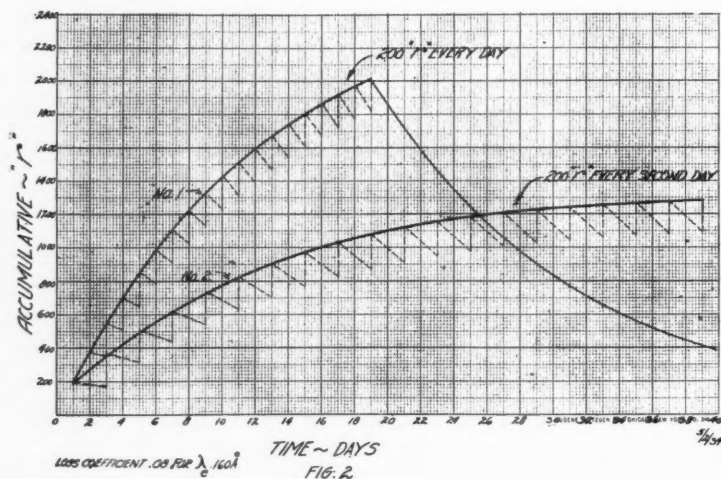
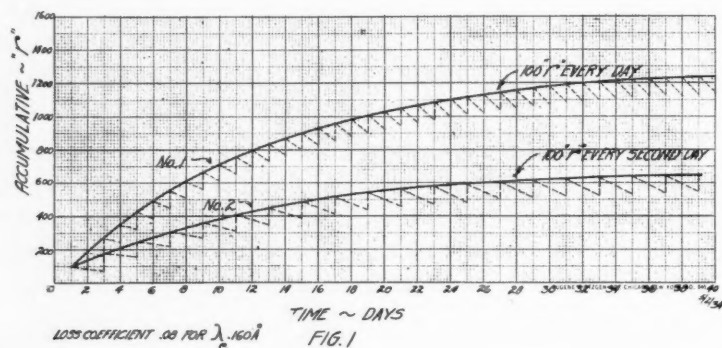
# THE TOTAL DOSE VERSUS THE CUMULATIVE DOSE IN RADIATION THERAPY<sup>1</sup>

By M. C. REINHARD and H. L. GOLTZ, Buffalo, New York

From the State Institute for the Study of Malignant Diseases, Buffalo, N. Y.,  
Burton T. Simpson, M.D., Director

IN the treatment of malignancy by means of the protracted method of applying radiation with hard x-rays of  $\lambda$  effective 0.16 to 0.12 Å, it is possible

ing). A mere statement of the total dose in this brief manner, without the qualifying factors of time over which the treatments are extended, the increment per



to administer exceedingly large total doses. In the literature we find reports of total doses as high as 7,800 r, yet the erythema dose with one application would amount to only from 1,200 to 1,500 r (tissue scatter-

treatment, or if more than one field of radiation is used, the dose per field (in which case the total dose refers to the entire amount of radiation applied to all fields), makes the analysis of the treatment data in terms of cumulative dose (or,

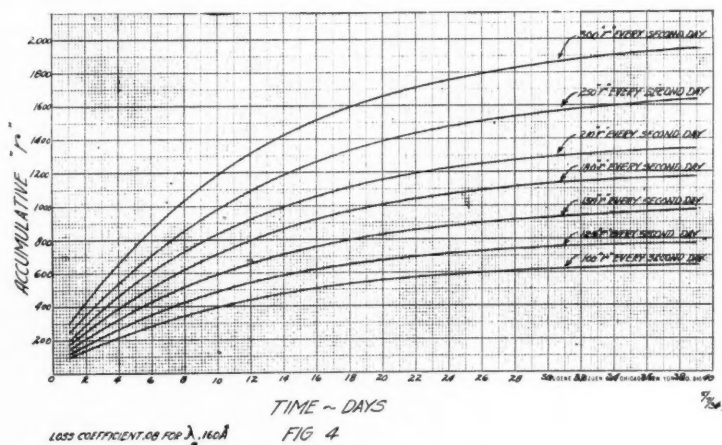
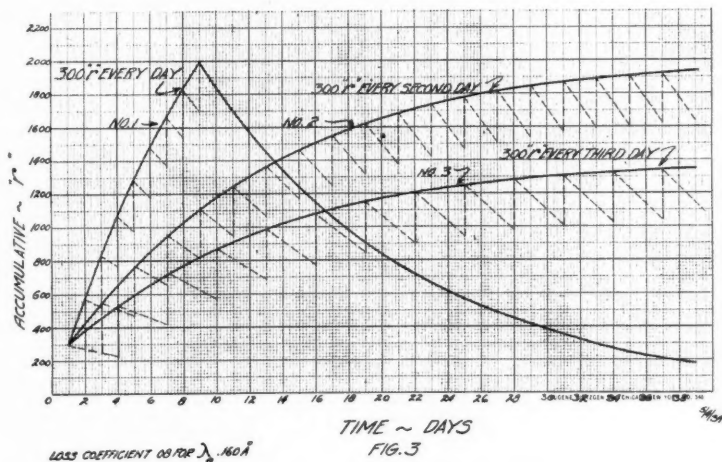
<sup>1</sup> Received for publication May 18, 1934.



as it is sometimes called, the effective dose) difficult, if not impossible.

In order to determine the relationship between the total and the cumulative doses, we have used increments and time

3. The cumulative doses in roentgens are plotted as the ordinates and the total time in days over which the treatments are extended are the abscissæ. The day of the first treatment has arbitrarily been



intervals which might be used in actual therapeutic practice, and have calculated the residual dose by means of a coefficient representing the loss of radiation effect of 0.08 as determined by Stenstrom and Mattick (1) for an x-ray beam of effective wave length of  $0.16 \text{ Å}$ . The results of these calculations, showing the cumulative dose as it changes from day to day, are arranged graphically in Figures 1, 2, and

called the first day when plotting the data, rather than zero. The day intervals for the treatments are indicated on each figure.

In the curves the solid line indicates the values immediately following each treatment, or, in other words, it represents the residual dose plus the increment of each treatment. The broken line indicates the daily depreciation on the downward slope

and the daily increment added by the perpendicular line. In actual practice, treatments cannot be carried out with the regularity indicated on these curves, because of Sundays and holidays, when, as a rule, no treatments are given. When an interruption of this sort occurs, the peak or cumulative value is lowered.

The cumulative doses with increments of 100 r and intervals for treatments of one and two days are shown in Figure 1.

In Figure 2 the increment is 200 r and the intervals are the same as in Figure 1.

In Figure 3 the increment is 300 r per treatment with intervals for treatments of one, two, and three days. Although 400 r represents an increment larger than ordinarily used in protracted radiation x-ray therapy, nevertheless we have calculated the cumulative doses for this increment, assuming intervals of one, two, and three days. With one-day intervals, a peak of 2,000 r is reached following the sixth increment. With two-day intervals, a peak of 2,000 r is reached following the ninth increment on the seventeenth day. A condition of equilibrium, however, is attained with three-day intervals at a level of 1,850 r on about the fiftieth day.

An upper limit of the cumulative dose of 2,000 r has been selected for these calculations. This may represent a dose considerably in excess of that ordinarily used to produce an erythema, but, as indicated in the protracted method, more pronounced reactions are to be desired, and it has been shown by Mattick (2) that doses of this order are necessary to produce reactions bordering on epidermolysis.

It is evident from the curves that in order to build up to a peak value for the cumulative dose of 2,000 r, daily increments ranging from 200 r up are necessary. Two hundred roentgens daily build up to a peak value of 2,000 r in nineteen treatments, while 300 r daily reach the same peak in nine treatments and 400 r with six daily increments. However, with any other combination of these increments and time intervals, a peak is never obtained, as

may be seen from the curves. Instead, the cumulative value builds up to a definite level which remains unaltered with subsequent additional increments. This condition we have called equilibrium, being a level where the rate of falling off of the radiation effect is compensated for by that added each treatment. When such a condition is reached, the total dose will increase progressively with subsequent increments, whereas the cumulative dose remains constant, and as a result the relationship between cumulative and total dose cannot be expressed in simple terms. This is better expressed in tabular form (see Chart I). This state of equilibrium in the tissues with respect to radiation is comparable to a certain extent to that produced by the saturation technic. The level of the point of equilibrium, however, is dependent on both the magnitude of the increment and the time between successive treatments.

CHART I.—THE CUMULATIVE DOSE IN RESPECT TO THE TOTAL DOSE WITH THE VARIOUS INCREMENTS AND INTERVALS

Dose		Increment r	Interval days	Total days	Status
Total r	Cumulative r				
7200	1850	400	3	50	Equilibrium
6000	1940	300	2	40	Equilibrium
4200	1350	300	3	40	Equilibrium
4000	1290	200	2	40	Equilibrium
4000	1240	100	1	40	Equilibrium
3800	2000	200	1	19	Peak
3600	2000	400	2	17	Peak
2700	2000	300	1	9	Peak
2400	2000	400	1	6	Peak
2000	650	100	2	40	Equilibrium

In Figure 4 there is assembled a series of curves, showing conditions of equilibrium at various levels of from 640 r up to 1,950 r, and the combinations necessary to produce these conditions.

Whether the combinations of increment and interval resulting in the formation of a peak value or those resulting in a condition of equilibrium, represent the more satis-

factory clinical procedure, is beyond the scope of this paper.

#### SUMMARY

1. The statement of total dose alone is insufficient, when protracted radiation treatments are reported. In respect to the skin effects, this report should include, in addition to the usual factors of quality of the beam and the intensity in r per minute, such information as the increment per treatment per field, and the interval for treatments of the same field.

2. Calculated on the basis that 0.08 represents a loss coefficient for hard x-rays, the information from the curves

indicates that an increment of at least 200 r daily is necessary in order to build up the cumulative dose to a peak of 200 r or more. All other combinations of increments less than 400 r and varying time intervals, except as noted in the preceding sentence, and 400 r with two-day intervals, produce a condition of equilibrium in the tissues, when the loss of radiation effect per day is equal to the increment added.

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# TECHNIC OF TREATMENT OF CANCER OF CERVIX WITH RADON<sup>1</sup>

By FRANK EDWARD SIMPSON, M.D., Chicago

THE character and extent of the tumor and the technic of treatment are the two most important factors in the prognosis of cervical cancer under radium.

If the cancer is confined to the cervix

than the healing of cervical carcinoma when the local conditions are not too unfavorable. As much depends on the technic, we wish to discuss briefly some of the various ways of using radium.

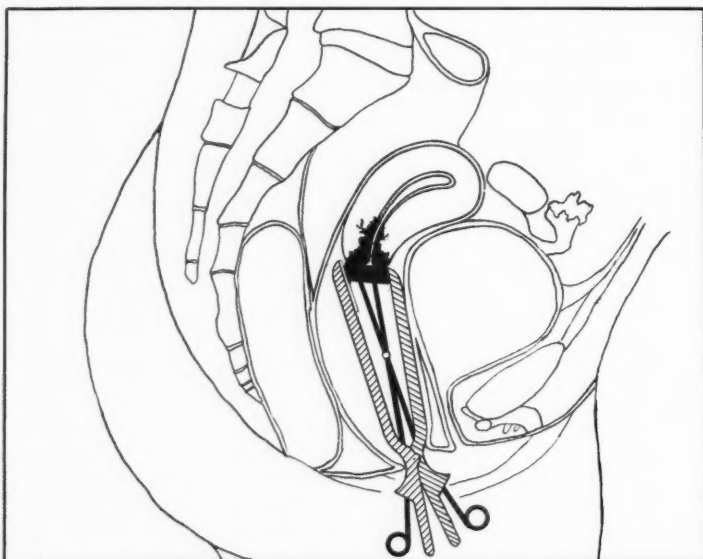


Fig. 1. One thousand mc. against cervix. A gold plate protects rectum. Speculum and forceps holding radon left in place during treatment (diagrammatic).

and is not made to metastasize by injudicious handling or treatment, the ultimate results are good in a considerable percentage of cases. If the cancer has spread slightly to the parametria or adjacent vaginal wall, the ultimate results may still be good provided the extensions of the growth are within the effective field of local irradiation.

If the growth has extended to the lymph nodes beyond the effective field of local irradiation, the ultimate results are poor.

Nothing in medicine is more striking

<sup>1</sup> Read before the American Congress of Radiology at Chicago, Sept. 25-30, 1933.

1. *Shall radium or radon be used?*—In giving intra-uterine treatment for cervical cancer radon has the advantage of being much less bulky than radium. We believe the cervix should never be dilated as long as active carcinoma is present. Radon can be introduced in a tube so small that cervical dilatation is unnecessary. The possession of sufficient quantities of radon makes the aramentarium much more flexible, but the effects of radium and radon are, of course, the same.

2. *Some recommend the use of small quantities of radium, such as 25 or 50 milligrams.*—The application of small



quantities for long periods of time is based on the theory of increased sensitivity of the cancer cell during mitosis. We believe, however, that the application of small quantities of radium for long periods of

*several successive days.*—We believe this procedure adds tremendously to the dangers of infection and metastasis. If the uterine canal has been invaded once, we believe further intra-uterine treatment

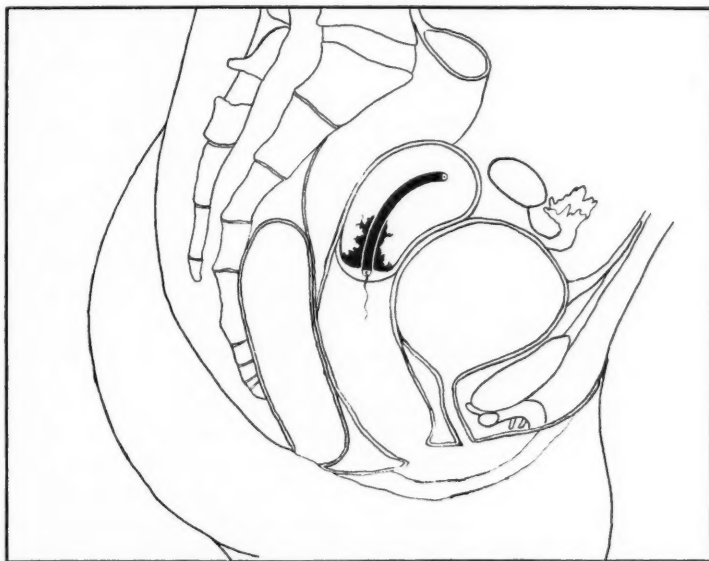


Fig. 2. Six hundred mc. in slender flexible lead tube in uterine canal. Introduced without dilatation after cervix becomes patent (diagrammatic).

time to metastasizing cancer of mucous membranes is a mistake, because of the traumatism and increased danger of metastasis. We have gradually adopted, therefore, the practice of using large quantities of radon, such as 1,000 mc., for short periods of time.

3. *Dilatation of the cervix.*—If the cervical canal is obscured or obstructed by the cancer, as frequently happens, it is impossible to introduce a tube into the uterine canal without a good deal of traumatism. Attempts to dilate the canal cannot but add to the danger of metastasis by opening up lymph and blood channels. We believe, therefore, intra-uterine treatment should be delayed until treatment against or outside of the cervix has rendered it patent.

4. *Some operators have advocated the daily insertion, withdrawal, and replacement of the intra-uterine applicator on*

*should be delayed for a period of at least six weeks.*

5. *Implantation of radium needles in the cervix or parametrium.*—We believe the implantation method of treating cancer should be limited to small, well circumscribed lesions which experience has shown do not yield well to surface irradiation. In the presence of a markedly infected field such as is common in cervical cancer, the implantation method may cause death from infection. The dangers of inducing metastasis are also very obvious. We advise strongly, therefore, against the current practice of implanting the cervix.

6. *Dosage.*—Unfortunately dosage cannot be standardized because no definite dosage is applicable to all cases. In planning dosage one must consider the location, size, and contour of the lesion.

We think the present tendency is toward too much irradiation. Some recommend

5,000 or more mc.-hrs. to the interior of the cervix, a dose which we regard as very excessive.

Using four portals of entry (two lateral fornices, inferior aspect of cervix, interior of uterus), we believe a total dosage of 6,000 mc.-hrs. should seldom be exceeded.

#### TECHNIC

We think it is futile and unnecessary to give preliminary douches or other treatment under a mistaken notion that one can "clean up" the field. The patient is in danger if we grasp the cervix with the tenaculum forceps or curette or cauterize the growth. Dilatation of the cancerous cervix should never be practised. We are opposed to making a trough for the insertion of radium tubes or to any sort of partial operation on the cervix when there is a certainty—a suspicion, even—of cancer.

Our method of attack is by surface irradiations against the cervix and lateral fornices and within the uterine canal with a large quantity of radon for a minimum of time. We believe the best results are obtained by using, as far as possible, the "selective" rather than a too "caustic" method. "Burns" should be sedulously avoided.

The cervix is exposed very carefully with a long bivalve speculum. A gold plate, 4 mm. thick, is then applied to the inside of the posterior blade of the speculum relatively to protect the rectum. An applicator containing approximately 1,000 mc. of radon is grasped with an 8-inch rat-toothed forceps and placed carefully against the cervix or in one lateral fornix. The radon applicator should be large enough to cover the entire growth.

We fill the speculum with gauze packing and leave the speculum and forceps carrying the radon in the vagina during the

entire irradiation, which may last only fifteen or twenty minutes. One strip of a T-binder dependent from the patient's shoulders holds the speculum and a second strip holds the forceps carrying the radon firmly but gently in position. The technic must, of course, be modified to suit individual cases.

In a few days a second irradiation is given against the cervix or in the other lateral fornix. These irradiations are continued until the estimated dose has been given.

When the cervix becomes patulous (which may occur in a few days or weeks), we introduce a flexible lead tube containing the radon into the entire uterine canal, without anesthesia and without pulling down or dilating the cervix. Being readily bent and only 4 mm. in diameter, the lead tube containing the radon can be introduced as easily as a sound. A tube 7 cm. long and containing 600 mc. of radon may be left in the uterus four hours, but we regard this as a maximum dose. The total dosage against the cervix and in the lateral fornices should not ordinarily exceed 3,000 millicurie-hours.

The entire local irradiation may be carried out in about three weeks. The pelvic girdle may be irradiated in the usual way with the radium bomb and x-rays, but it is difficult to determine how much this type of treatment influences the final result. If cancer cells have migrated to the deeper parts of the pelvis beyond the effective field of local irradiation, all types of so-called "deep radiation therapy" are, as a rule, palliative only.

Most patients remain ambulatory during the entire treatment. Patients too far advanced for strong "curative" measures should receive only palliative irradiation, as nothing is gained and much harm may be done by severely injuring normal tissues.

## A ROENTGEN EXAMINATION OF THE CHEST OF 500 NEWBORN INFANTS FOR PATHOLOGY OTHER THAN ENLARGED THYMUS<sup>1</sup>

By LEON SOLIS-COHEN, M.D., and SAMUEL BRUCK, M.D., Philadelphia

THE authors, believing that the study of pulmonary roentgen pathology must begin with the newborn infant and continue throughout life, have undertaken to study the various shadows depicted upon roentgen films in the newborn infant, and present their findings: (1) of existing conditions within the thoracic cage other than enlarged thymus; (2) a complete thymus study; (3) the determination of any conditions that would give rise clinically to symptoms that would be confused with the so-called dyspnea of thymic origin. The following report deals with the first phase of this study.

For the past four or five years, with the co-operation of the obstetrical department, a roentgen examination of the chest of every child born at the Jewish Hospital has been made within the first few days of its life, to determine the presence or absence of an enlarged thymus.

Within the last two years, the method adopted for this examination has been modeled after the one used by Pancoast and his confrères at the University of Pennsylvania Hospital. Each infant is examined in inspiration and in expiration and in the lateral as well as the antero-posterior position, but in the recumbent and not in the erect posture. This change was made because we felt that the newborn infant is always recumbent, and of its own volition and accord cannot assume any other position. Therefore, the effects of an enlarged thymus on the tracheal lumen must be determined in the recumbent position to judge whether or not this produces compression or displacement of the trachea in the posture natural to the patient.

The results of this thymus study are in the process of investigation and will be reported at some future time.

During the last winter [1932-33], one of our Philadelphia roentgenologists, E. J. Bertiu, presented before the Philadelphia Roentgen Ray Society, films of about ten newborn children which he thought showed a possible pneumothorax. This stimulated us to review our vast material of chests of newborn infants, to see whether we could find similar evidence of pneumothorax, and incidentally any other abnormalities in the chests aside from enlarged thymus.

Five hundred cases were taken, within the first week of life, without any special selection. They were listed for the following abnormalities in both the inspiratory and expiratory phases, namely: pneumothorax, atelectasis, and the amount of air in the esophagus. Incidentally, we thought that we would investigate the cardio-thoracic ratio, the shape of the heart, and any abnormalities that might be encountered. These films were made at a distance of three feet and therefore the estimation of the cardio-thoracic ratio was not as accurate as if these patients had been examined in the erect posture at a distance of six feet.

*Shadows of Extrinsic Origin.*—At the out-set, certain shadows were encountered which could not be explained satisfactorily. There were sharply defined lines noted on some of the films, which when seen on the chest only, could readily be mistaken for the outline of a non-expanded lung or compressed lung, which could conceivably be produced by air in the pleural cavity. Inasmuch as we sometimes found similar lines continuing into the abdomen or confined entirely to the abdomen, we took successive radiograms of a number of patients, and found that these lines were definitely due to skin folds, or to folds in the material used between the patient and the x-ray cassette. (See Fig. 1.)

<sup>1</sup> Presented before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.

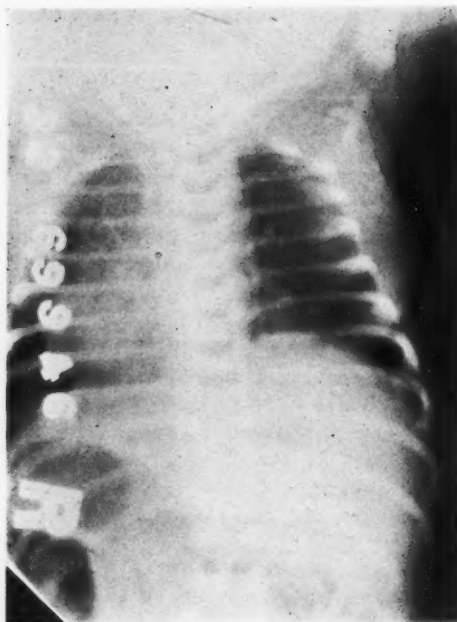


Fig. 1. Extrinsic line in right lung, due to a skin fold.

*Shape of Heart.*—We divided the shapes of the heart into three types, the globular, the pear-shaped, and the intermediate. It was found that in 402 cases, about 80 per cent, the heart was pear-shaped, much like the adult heart; in 90 cases, about 18 per cent, the heart was globular, and that the cardiac silhouette was intermediate between these two types in about 2 per cent of the cases. This classification of cardiac contour differs somewhat and is somewhat simpler than that noted by Farrell,<sup>2</sup> but in the main it corroborates his findings.

One would suppose that during the expiratory phase, when the diaphragmatic shadows are elevated, the heart shadow would also broaden out, and measure more than in the inspiratory phase. Farrell found such to be the case. It is definitely acknowledged by the cardiologists that the phases of respiration have more effect on the size of the cardiac shadow than does

systole or diastole. As a matter of fact, in the present investigation, the cardiac measurement decreased in the expiratory phase in 226 of the 472 cases measured, *i.e.*, in 48 per cent. It increased in 40 per cent, and remained practically the same in 7 per cent. This is somewhat at variance with the findings of Farrell, noted in the article quoted above, in which he states that in all his cases the chest narrows and the heart enlarges in expiration. The authors have endeavored to account for this and have thought that the following might be an explanation.

The size of the chest during respiration is determined by various factors, such as the movements of the diaphragms and the movements of the bony costal cage. In the inspiratory act, when the ribs are elevated, the transverse diameter of the chest would naturally be greater. If the costal cage does not participate to any great extent in the inspiratory act, and the changes in the size of the intrathoracic cavity are effected mainly by the movements of the diaphragms, then it is possible that during the inspiratory act, when the diaphragm descends, the transverse diameter of the heart would not be increased or may even be decreased. This is not at all surprising, for in the infant the heart lies transversely rather than longitudinally, as in the older child and adult. Hence, the apex, and for that matter any part of the heart, does not, as far as we know, at all come in contact with the diaphragm.

The authors believe that this would account for the fact that in some cases the transverse diameter of the chest increased, in some cases decreased, and in some cases remained constant. However, we must remember that respiration in infancy is chiefly abdominal rather than thoracic.

In reference to the cardio-thoracic ratio, this varied somewhat in the 500 cases. In inspiration, in 24 per cent it was below 50 per cent and in 68 per cent it was above 50 per cent. In expiration, in 13 per cent it was below 50 per cent and in 79 per cent

<sup>2</sup> Farrell, John T., Jr., The Roentgen Appearance of the Chest of the Newborn Infant. *Am. Jour. Roentgenol. and Rad. Ther.*, August, 1930, 24.



it was above 50 per cent; 7 per cent have no measurements. The probabilities are that the cardio-thoracic ratio in these practically normal infants did not vary materially from the normal adult's. Farrell makes a similar statement. Whether or not the relative size of the thymus affects the cardio-thoracic ratio will be investigated in our thymus study.

*Air in the Esophagus.*—An interesting finding was the rather frequent occurrence of cases in which the esophagus was distended with air. As a general rule, where air was present in the esophagus, it was noted both in the inspiratory and expiratory phases, sometimes being more marked in one than in the other. The presence of air in the esophagus did not depend upon the fact that the infants were examined immediately after feeding. Practically all of them, those showing air in the esophagus and those free from air in the esophagus, were examined at the same time of day, and the same period after feeding. These examinations were made in the majority of cases at least one and one-half hours after meals. The presence of air in the esophagus in itself should not be surprising inasmuch as the infants are probably constantly swallowing air, but even so it is seen much more frequently than in the older children or adults. Why the esophagus in newborn infants should retain air sufficiently long to be visualized on an x-ray film is not apparent, except the fact that in newborn infants the cardio-esophageal opening in the stomach is much more patulous than in the adult and would allow the regurgitation of stomach air into the esophagus. Still, amount or presence of air in the esophagus was not dependent upon the presence or amount of air in the stomach since there were many cases in which air was not present in the stomach and was noted in the esophagus. The fact that the infants are examined in a recumbent position may probably help to explain this finding, since it is well known that the esophagus will retain its contents longer in the recumbent position than in the erect position. (Figure 2 shows a large



Fig. 2. Air in the esophagus.

amount of gas present in the esophagus, producing esophageal distention. This is not evidence of cardiospasm, as in the infant spasm could not be of such intensity as to prevent air getting into the stomach. Babies that cry a lot or suck their fingers swallow air readily and the patulousness of the cardio-esophageal sphincter is more responsible for the air than the opposite condition, namely, spasm.)

*Interlobar Pleura.*—The National Tuberculosis Association appointed a committee to determine what should be considered a normal appearance of a chest, as depicted on a roentgen film. This committee decided that a visible interlobar pleura on the right side, which, of course, is supposed to indicate thickening of the pleura, should be considered a normal finding. If we are to suppose that in order to become visible on an x-ray film, the interlobar pleura on the right side must be

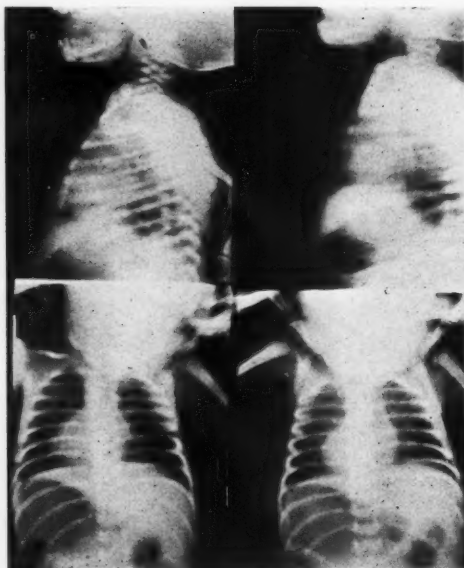


Fig. 3. Shadow simulating pneumothorax on right side, present only in expiration.



Fig. 4. Anencephaly, still-birth. Note that the thoracic cage is identical in size with the unexpanded lungs.

thickened, it follows that this shadow should never be visible on the film of a normal newborn infant, since the possibility of a thickened pleura arising in intra-uterine life is very remote. Yet in 37 cases of the 500 (that is, 7 per cent), the interlobar pleura is distinctly visible. Our observation in respect to the shadow of the thickened pleura, confirms the finding of Charles A. Weymuller, A. L. L. Bell, and A. A. Trivilino,<sup>3</sup> who reported the fact that in full-term infants, the line of interlobar pleura was found quite regularly; however, we did not find it quite as regularly as we were led to infer from the report of these writers.

**Pneumothorax.**—In 11 cases of the 500, approximately 2 per cent, a distinct line could be seen on the right side in four cases and on the left in seven cases, which had the appearance of the external boundary of a compressed lung, as is so frequently

seen in artificial pneumothorax as applied in the treatment of tuberculosis. The lung-field internal to this line showed definite markings indicative of lung structure, whereas in the lung-field external to this line there was practically a complete absence of lung markings. It presented, indeed, the exact appearance of air in the pleural cavity. We are not prepared to say whether or not this is a correct interpretation. It would seem reasonable to suppose that if there actually is a pneumothorax, certain criteria should be present. Whatever the condition be, it was undoubtedly present at birth. Since some of these cases were examined three to five days after birth, at least one or two by the law of averages should have presented concomitant fluid in the pleural cavity, due to pleural irritation, as so often happens in pneumothorax, particularly of the spontaneous type. No appearance or symptoms suggesting fluid were present in any of these cases. Again, the evidence of pneumothorax should be present in both expiration and inspiration. The signs

<sup>3</sup> Weymuller, Charles A., Bell, A. L. L., and Trivilino, A. A., Roentgenographic Changes in the Thorax of Normal Premature Babies. *Am. Jour. Dis. Child.*, March, 1930, 43, 585-593.

should be more marked and seen more frequently in the expiratory than in the inspiratory phase. It is conceivable that if there is only a small amount of air in the pleural cavity, expansion of the lung during inspiration would produce a closer approximation of the parietal and visceral pleura, and at times might obliterate the evidence of the pneumothorax entirely. As a matter of fact, the appearance suggestive of air in the pleural sac was seen in inspiration in nine cases, and in expiration in only three cases.

It is also rather unlikely that were definite pneumothorax present in these cases, there would be complete absence of clinical signs, such as dyspnea, cyanosis, and cough. In none of these 11 cases was clinical evidence present, and the observation was made in all only because we were searching for it.

Furthermore, one should be able to find some cause for the presence of air in the pleural cavity before definitely concluding that it is present, however suggestive may be the shadows observed. It is conceivable that artificial means of resuscitating an infant could produce a rupture of some of the air vesicles, through high intrapulmonary pressure from forcible inflation. A careful analysis of the history in these failed, however, to reveal even one in which artificial resuscitation had been employed. One might suppose that the pneumothorax had occurred spontaneously, from forced inspiratory effort on the part of the infant itself at birth, but in that case there should be a larger proportion of instances than we were able to find. Fortunately for these infants, none of the cases have gone to autopsy. Therefore, this method of comparison and corroboration has not been available. However, while it cannot be stated dogmatically that these shadows are demonstrative of pneumothorax, neither can pneumothorax be definitely excluded. It is logical, nevertheless, to suppose that they may represent some other condition, which we are not as yet able to recognize. Meanwhile, careful and



Fig. 5. Congenital absence of the left lung. Note the size of the left thoracic cage.

more general studies of cases of this sort should be made. It would be well, when possible to do so safely, to re-ray such patients. Unfortunately, since this study was undertaken, no case has been encountered that showed the shadows under discussion; but opportunities for further observation will undoubtedly occur, and the results of serial studies in such instances will be reported at some future time. (See Fig. 3.)

*Atelectasis.*—In our series of 500 cases, we found 20 cases (4 per cent) that showed failure of complete expansion in both lungs. Weymuller, Bell, and Krahulik<sup>4</sup> found one infant in twenty-five who showed anything suggesting atelectasis, which is in accord with our observations. The roentgen and pediatric literature recently has been paying a good deal of attention to atelectasis in the newborn infant. In order to distinguish the collapse of air vesicles consequent upon bron-

<sup>4</sup>Weymuller, C. A., Bell, A. L. L., and Krahulik, L., Roentgenographic Changes in the Thorax of Normal Newborn Babies; Daily Roentgenographic Study of 25 Normal Babies during First 14 Days of Life. *Am. Jour. Dis. Child.*, 1928, 35, 837-855.

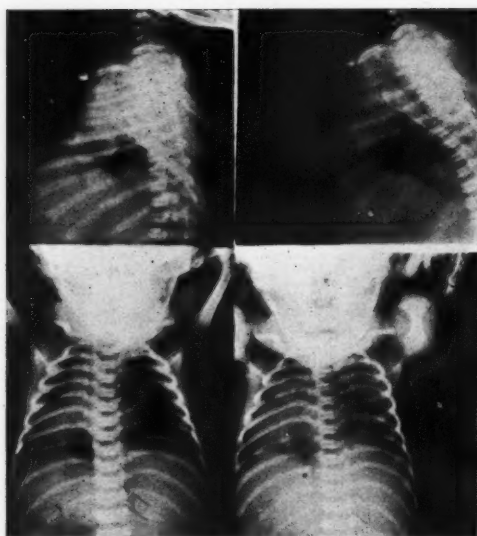


Fig. 6. Anectasia, 24 hours after birth. Note the lobular areas of non-expansion on the right side.

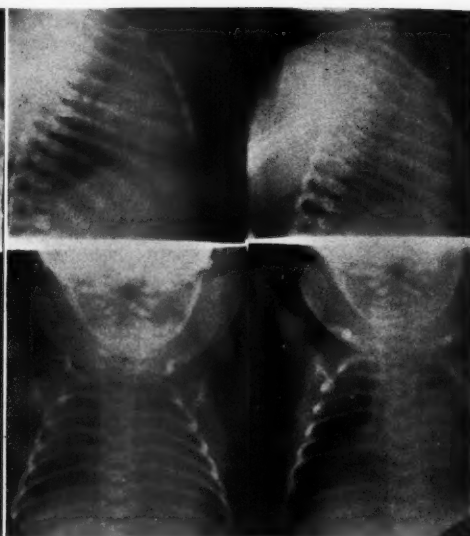


Fig. 7. Anectasia, 48 hours after Figure 6. Note expansion of right lung.

chial obstruction from the lack of aeration due to a failure of expansion, we are inclined to use the term "non-expansion of the lung" for this latter condition, or the Greek term, *anectasia*, restricting atelectasis to the obstructive condition (Figs. 6 and 7). There is no doubt that failure to expand the lung completely occurs much more frequently than we formerly believed, and doubtless many of the cases of cyanosis that were assumed to result from thymic enlargement, were instances of such failure.

Should one expect to find the same roentgen signs of non-expansion of the lung in the newborn infant as are found in the atelectasis resulting from bronchial obstruction? The writers believe not. In the still-born infant, the pulmonary fields present a uniform density that fills up the entire thoracic cage (Fig. 4). The size of the cage is identical with the size of the unexpanded lungs. When the lungs are expanded by the intake of air after birth, the thoracic cavity expands commensurately to accommodate the increased pulmonary volume. Hereafter, the thoracic cage grows with the size of the intra-pulmonary contents, but can no

longer diminish its size to conform to a decrease in pulmonary structure from obstructive atelectasis. This is well shown in Figure 5. It is the roentgenogram of a newborn infant with congenital absence of the left lung. On the right side where normal pulmonary structure is seen, the chest cavity has enlarged and expanded to accommodate the increased pulmonary volume. On the left side where no lung is present, the thoracic cavity remains flattened, unexpanded, and just the same size as it was in intra-uterine life. If then, in adult life, an atelectasis occurs in one lung or a portion of the lung, diminishing its volume, the space in the thoracic cage must be filled up by an ascent of the diaphragm and moving over of the heart and mediastinal structure to the side of the lesion; and increased aeration of the opposite lung-field with increased size of the air vesicles. In the newborn infant, however, before complete expansion, the thoracic cage is as large as the volume of the chest organs. Hence, if there be failure of complete expansion of a lung or a portion of a lung, additional or displaced structures are not needed to fill the ex-



tra space. The pronounced cardiac and mediastinal displacements that are seen in the atelectasis of bronchial obstruction do not then occur. Further non-expansion of a whole lung in the newborn is rare. The form of non-expansion which usually occurs, involves either a lobe or small lobular areas throughout one or both lung-fields. The authors have traced some of these cases by daily examinations or examinations every 48 hours and have demonstrated very clearly the gradual expansions of these non-expanded portions of the lungs. They can, therefore, definitely state that while cases do occur in which there is partial non-expansion of the pulmonary fields, it is in the majority of these cases, a temporary condition only, and gradually clears up during the first week of life. Of all the cases in which there was failure of expansion, not one was permanent, nor were any deleterious after-effects noted.

One important observation was brought out by the method of examination in both the inspiratory and expiratory phases. One might suppose that the evidence of atelectasis would be much more marked during expiration than during inspiration, because a part of the lung not fully expanded would show more evidence of aeration during the time of intake. Again, small areas of non-expansion might be obscured by complete aeration of contiguous air vesicles during the inspiratory act. In our group of 20 cases of non-expansion, four of them were noted only during inspiration, one of them only during expiration, and the remainder during both inspiration and expiration.

It is very difficult to determine in the four cases, in which non-expansion was

detected, why this should be so. One might well question whether a mottled increase in density throughout a lung-field or a more or less localized area of increased density in a lung-field could be a non-expansion of the lung, and yet disappear during the expiratory phase. Because of these four cases, we are inclined to believe that a definite diagnosis of non-expansion of the lung should only be made if this evidence is present in the expiratory phase or during both expiration and inspiration. Fortunately, if the infant is examined in only one phase of respiration, it is usually in expiration, because it is so much easier to catch a crying infant in that phase.

#### SUMMARY

If this study has not revealed any very marked or very unusual pathologic or abnormal processes, it has directed attention to some rather interesting observations. Certain it is that we must keep in mind the possibility of failure of expansion of the lung, or anectasia, as a source of those symptoms that heretofore have nearly always been ascribed to enlarged thymus. We have also come to the conclusion that much more may be gained in examination of the chest of these newborn infants, and much more intelligent interpretations made of those films, if taken both during expiration and inspiration, even where the question of enlarged thymus does not enter. The authors are very desirous to have other roentgenologists note the shadows which may be interpreted as possible pneumothorax and help to determine whether or not there actually is any air in the pleural sac in infants showing the appearance described.

## PELLEGRINI-STIEDA'S DISEASE: CLINICAL AND ROENTGENOLOGIC CONSIDERATION<sup>1</sup>

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### INTRODUCTION

**F**OLLOWING trauma, peri-articular calcification is frequently seen in the regions of the shoulder, elbow, hip, and knee. In the shoulder, this usually occurs in the subacromial bursa or in the supraspinatus tendon after a tear. Calcification and ossification are seen in the bursæ of the elbow or in the soft tissues after extravasation of blood accompanying fractures. The bursæ in the region of the greater trochanter of the femur are subject to trauma from direct blows: calcification is occasionally found here. The bursa between the gluteus maximus muscle and the trochanter is most often the seat of inflammation in this region.

The knee is subjected to more trauma perhaps than any other joint of the body for the reason that it depends entirely on ligamentous structures for its stability. Because of its important functions of weight-bearing and walking, relatively minor affections are attended by great disability. It is probably for this reason that calcification and ossification, in the region of the medial femoral condyle, are considered to be important disease entities—first described by Pellegrini, in 1905, and now known as Pellegrini-Stieda's disease.

### HISTORICAL

In 1905, Köhler and Pellegrini (8) independently reported this condition. Köhler's description was radiographic; it was published in an atlas on normal and pathologic anatomy. Pellegrini gave a more complete description of the disease including the history and morbid anatomy. Neither of these descriptions received much publicity: Köhler's because it was in an at-

las on anatomy, and Pellegrini's because it was in a not widely known journal which is no longer published and is now difficult to procure. To Stieda (11) belongs the credit for bringing this condition effectively before the medical profession. In 1907, he reported six cases of the disease before the third German Congress of Radiologists, at Berlin. He believed that fracture was the basic cause of the disease. This was produced by a portion of the internal condyle being broken off by external force, or by muscular contraction.

More recent authors have disagreed with this conception of the syndrome. The experimental work of Schüller and Weil (3) has thrown doubt upon Stieda's original idea of fracture as the underlying cause. Vogel, Preiser, and others have a different conception. Many articles dealing with this condition have appeared in the medical literatures of France, Germany, and Italy. So far as we have been able to determine, Kulowski (5) has written and published the only article in English describing this disease. (See note on page 188.)

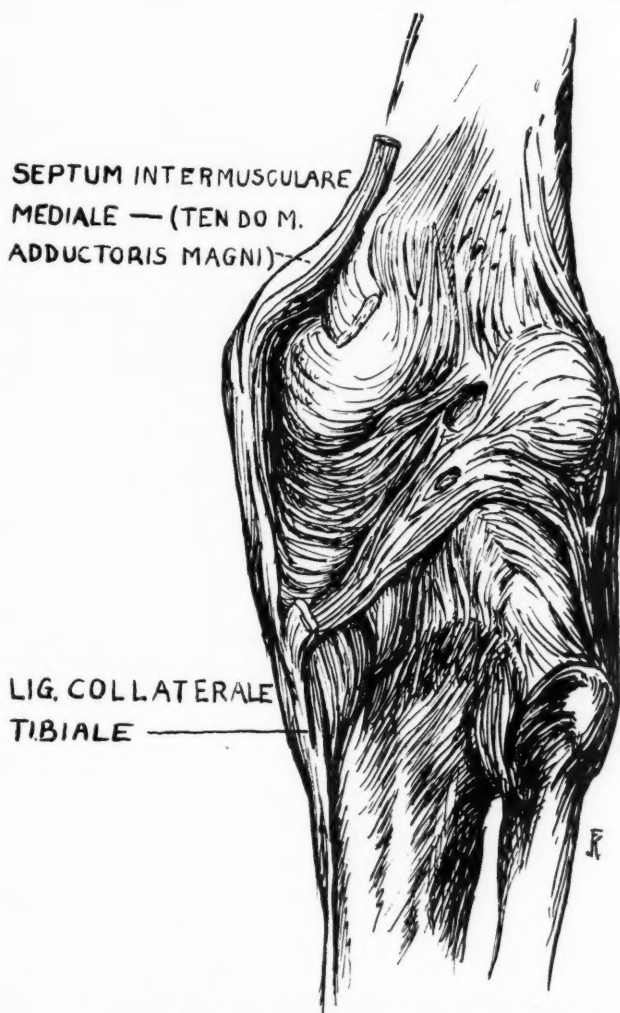
### ETIOLOGY

Authors have generally agreed that the cause of this calcification is trauma. This is the result of a direct blow over the medial femoral condyle or a torsion of the knee when flexed and abducted. The medial aspect of the knee is subject to these injuries because of the following reasons: First, the distortion of the joint by forced abduction of the leg; second, the normal slight valgus position of the knee; third, the strong defensive contraction which occurs in the adductor and quadriceps muscles during stress; fourth, injury to the deep and superficial anastomotic vascular network which gives rise to the hematoma. The site of

<sup>1</sup> Received for publication May 8, 1934.

the calcification which arises from the hematoma can be seen from Figure 1. The structures involved are the internal lateral ligament or the tendons of the adductor muscles.

trauma a metaplasia from fibrous tissue to osseous tissue occurred. Stieda (11) described a fracture. He maintained that a fragment was blasted off the internal femoral condyle, and supported his conten-



### RIGHT KNEE - POSTERIOR VIEW

Fig. 1. Right knee from behind. Anatomic structures involved in Pellegrini-Stieda's disease, *i.e.*, the internal lateral ligament and the adductor insertion.

#### **PATHOLOGY**

The pathogenesis from the trauma to the full blown picture has been the subject of much discussion and numerous hypotheses. Pellegrini (8) believed that as a result of the

tion by stating that his cases showed crepitation and increased lateral mobility. Milesi (6) held that a calcification occurred in the soft tissue similar to that seen in the neighborhood of other joints. Bistolfi (1) believed that a definite periosteal

tear and displacement took place from which the new bone was formed. Ewald and others felt that the best explanation was that of a myositis ossificans. Some authors ascribe the lesion to a tear of the superior attachment of the tibial collateral ligament, others, to the adductor attachment.

Gay-Bonnet and Stefanini (4) consider it to be a local calcification. There is injury with an ossifiable medium, *i.e.*, an interstitial hematoma. Bistolfi (1) believes injury of the anastomotic vascular network in the deep and superficial structures of the knee may be a factor in producing a marked congestion in this region. In addition to the rich blood supply and the connective tissue present, the condyles furnish an ample supply of calcium for the new ossification. According to Gay-Bonnet and Stefanini (4), the following then occurs: the degenerating red blood cells are replaced by embryonal cells; congestion and edema coexist; all factors necessary for calcification are present. The calcification is thus explained by the presence, locally, of embryonal cells, congestion, edema, and the nearby storehouse of calcium.

Schüller and Weil, in 1923, injected an opaque substance into the tendon of the adductor magnus muscle in fresh cadavera. Roentgenograms of the knees were made. The films showed a semilunar shadow with its apex toward the greatest protrusion of the internal epicondyle, and with its base toward the thigh muscles. The substance was then injected in the internal lateral ligament of the knee, and the shadow in the films assumed an elongated shape in a position parallel to the epicondylar margin. The superior limit stopped suddenly just below the epicondyle. From these experiments, the authors concluded that the origin of the osseous mass was not from periosteum, but from connective tissue—a metaplasia resulting from a contusion or a tear caused by a strong contraction of the adductor magnus muscle.

The early conception of fracture of the internal condyle has been largely abandoned. The bone-like tissue which de-

velops following injury is believed by Bistolfi (1) to arise from periosteal displacement. However, he considers the surrounding connective tissue as a more important factor in producing the new growth. According to him, the internal lateral ligament is the most frequent site of the calcification: next in frequency is the adductor insertion.

Kulowski (5) agrees with Bistolfi, Gay-Bonnet, and Stefanini that myositis ossificans is the basic pathologic process. His operative findings substantiate this.

#### SYMPTOMS AND COURSE

Examination soon after injury reveals local tenderness to palpation, swelling, and limitation of motion. A hematoma may be demonstrable. Hemarthrosis or hydrarthrosis are rarely found. X-ray films are negative at first, but those taken two to four weeks following injury reveal the calcifying area. Subsequent films show increasing density (this is well illustrated in Case 5). Within a few days, the pain and swelling subside but disability and limitation of motion are quite likely to persist for from one to two years. Atrophy of the adductor muscles may occur.

#### DIAGNOSIS

In injuries in the region of the internal femoral condyle, this disease must always be considered. The diagnosis of Pellegrini-Stieda's disease rests upon the history, physical and x-ray findings. The condition is always traumatic in origin, resulting from a direct blow over the internal femoral condyle or a violent strain of the internal lateral ligament. The disease is frequently found in industrial workers, usually men, between 25 and 40 years of age. It is rare in women and almost always unilateral.

The physical findings in a typical case are swelling, local tenderness, and limitation of motion. Hematoma may be demonstrable. Hydrarthrosis and hemarthrosis are very infrequently encountered. However, on physical examination, nothing may





Fig. 2. Case 1. Before treatment.

Fig. 3. Case 1. After treatment: calcification has disappeared.

Fig. 4. Case 2. Calcification of the internal lateral ligament.

be demonstrable. This is frequently the case and the examiner is much surprised later when x-ray films are made to see a well developed calcification over the internal femoral condyle.

The x-ray findings in a typical case are as follows: There is a crescent-shaped opaque body with the concavity directed toward the condyle, but separated from the latter by a clear space. The ends are often slender. The subjacent condyle presents a normal silhouette. Nothing is seen which suggests any deformity of or depression in the internal condyle such as might occur with an osseous tearing. A patient with the above history, physical and x-ray findings presents no difficulty to the physician, as a rule, in reaching a diagnosis. In making a differential diagnosis one must exclude fracture (rare) of the internal femoral condyle, internal derangement of the knee, para-osteal arthropathies in paraplegic cases, enchondroma, and supracondylar processes.

The roentgenogram will exclude fracture by demonstration of a normal silhouette of the medial side of the femur. Internal derangements of the knee usually show no

change demonstrable on the x-ray films. Para-osteal arthropathies in paraplegic cases can be ruled out by the history. Enchondromas and supracondylar processes can be eliminated by form, continuity with the shaft of the femur, and direction of growth. The diagnosis once established, prognosis and treatment must be considered.

#### PROGNOSIS

A small percentage of cases may be troublesome. The ultimate picture is often not seen for from one to two years. Persistent limitation of motion, with pain, past 90 degrees of flexion, and atrophy, especially of the adductor group of muscles, are the most frequent sequelae seen. Most cases do well under proper treatment.

#### TREATMENT

The treatment should include: (1) aspiration of the joint, if necessary; (2) immobilization of the joint, to permit repair of the lesion. If aspiration has been necessary, a compression bandage should be applied and immobilization accomplished

by application of a Cabot splint. If no joint effusion has taken place, a leg cast or a plaster cylinder is more comfortable. During the first week, the patient should be instructed to practise frequently active contraction of the quadriceps muscle to prevent atrophy.

Weight-bearing may be started the second week, provided the knee is supported by a compression, elastic, or felt and flannel bandage. It is not believed that this active motion will aggravate the lesion. Diathermy is by far the most valuable of the physical therapeutic adjuncts. It does no harm and often arrests the process in its development, and will sometimes promote resorption of the calcification. Massage may be permitted to the quadriceps region and the calf muscles, but is absolutely contra-indicated over or near the involved area. Many feel that massage is contra-indicated at any time, since if applied to or near the affected area it serves only to increase the congestion and edema. We feel it may be permitted to the above mentioned areas, but only after the second week. Surgery is indicated only in old cases, when the size of the mass interferes with the mechanics of the joint, but is to be thought of only after the calcification has reached completion.

#### CASE REPORTS

Case 1. G. H., female, aged 38 years, was first seen on Feb. 14, 1933. Three weeks before, she had twisted her knee while doing calisthenics. No pain or disability was noticed until one day previous to her visit. She had been ice skating and quite active in the meantime. Examination revealed tenderness to palpation over the superior attachment of the internal lateral ligament of the left knee. There was slight increase in lateral mobility and pain in the extremes of motion.

X-ray films revealed a semi-lunar shadow of increased density near the median epicondyle of the femur, typical of the calcification in Pellegrini-Stieda's disease (Fig. 2). There was also some degenerative arthritis in the knee joint.

The patient was given diathermy locally and an elastic supportive bandage to the knee. Her activity was restricted for a short time. Symptoms entirely disappeared in ten days. She was last seen on March 10, 1934. There was no recurrence of symptoms. Progress x-ray films showed that the calcified deposit had disappeared (Fig. 3).

Case 2. L. H., female, aged 45 years, an arthritic (chronic proliferative) under treatment for symptoms referable to the right hip and knee. No history of trauma could be elicited. Few symptoms were associated with the knee. Marked limitation of motion was found. There was present a thickening of the soft tissues with local swelling and increased heat.

X-ray films showed calcification typical of Pellegrini-Stieda's disease. This was entirely an incidental finding (Fig. 4). No treatment was directed toward the calcification.

Case 3. F. S., male, aged 61 years, had been in a motor accident five years previously, in which he had sustained fractures of both legs. At the time of admission to this hospital he complained of stiffness of the left knee, which had been injured at the time of his accident. This was associated with arthritic symptoms in various other joints. Examination revealed no limitation of motion, but crepitus was elicited. Increased lateral mobility as compared with the opposite side was noted. X-ray films showed calcification near the median femoral condyle. The shadow measured 4 mm. wide by 3 cm. long. There was evidence of chronic hypertrophic arthritis of the knee joint present. We felt certain that this patient had sustained a tear of his internal lateral ligament at the time of his motor accident, which was overlooked because of his fractures and other major injuries (Fig. 5).

Case 4. G. K., male, aged 23 years, was admitted to the Orthopedic Clinic complaining of swelling and pain in the left knee joint, one week after a motor accident. He had been treated at the time of the accident for multiple lacerations, cerebral



Fig. 5. Case 3. Marked calcification of the internal lateral ligament.



Fig. 6. Case 4. Roentgenogram taken immediately after injury. No calcification is shown.



Fig. 7. Case 4. Roentgenogram taken two months after injury. There is calcification shown.

concussion, and contusions. After his discharge, he complained of symptoms in the left knee when he resumed his activity.

Examination disclosed effusion of the knee, pain on motion, increased lateral mobility, and pain on palpation along the medial aspect of the joint. X-ray films were negative, except for soft tissue swelling. Diagnosis of a torn internal lateral ligament was made. The knee was aspirated and 150 c.c. of blood and serum were obtained. A leg cast was applied for three weeks, after which time it was bivalved and motion begun (Fig. 6). A progress x-ray film taken two months later showed a shadow of soft tissue calcification, medial to the internal condyle of the left femur (Fig. 7).

The patient improved. The case was removed after four weeks, and a supportive bandage of flannel and felt was worn for three weeks. He was symptom-free and discharged as cured in three weeks.

Case 5. M. P., male, aged 46 years, was admitted to the hospital following a street

accident, with a head injury and a fracture of the right fibular head. He complained of some pain in the medial aspect of the right knee. A small amount of effusion was present in the knee joint.

X-ray film of the knee on admission showed the fractured head of the fibula. A leg case was applied for three weeks, after which time it was bivalved and a progress roentgen examination made. This showed an increased shadow of density in the soft tissues in the region of the internal femoral condyle. The effusion had disappeared; bakes were then started. Motion in the knee was limited to 10 or 15 degrees but improved with active exercises and physical therapy. The patient was discharged from the hospital on February 1 and followed thereafter as an out-patient, being last seen on March 5, 1934. X-ray films taken at that time showed a shadow not larger than before but of greater density. (Figures 8 and 9 are reproductions of films made at the time of the injury and eight weeks later, respectively.)

## MEDICO-LEGAL ASPECTS

The relatively large groups of cases of Pellegrini-Stieda's disease reported by European clinics indicate that it is not an

too, that cases should be followed for years to determine the permanent degree of altered function.

Maffei rates the disability resulting from this disease at from 5 to 10 per cent.



Fig. 8. Case 5. Roentgenogram taken three weeks after injury. There is shown a faint shadow of early calcification.



Fig. 9. Case 5. Roentgenogram taken eight weeks after injury. Note increase in density of calcification.

uncommon complication of industrial injury. Maffei (7) believes that it is much more common than suspected, because the trauma is mild or minimal. It must be equally as common in this country, particularly in industrial clinics.

The question of disability then is of prime importance. Since the lesion tends to become arrested after progressing to a certain point, complete restitution of function in many cases is not permitted except for a certain degree of adaptation by the individual.

Muscular atrophy, due to disuse in the painful stage of the disease, is said to occur. Milesi (6) thinks the estimate of the disability should be rated higher than that seen shortly after an accident because of possible subsequent atrophy. He feels,

Those cases of his which reached the supreme court were given 15 per cent disability. Others rate the disability from 5 to 50 per cent. It is generally felt, however, that the true figure lies between 5 and 20 per cent.

## DISCUSSION

In this article we have endeavored to set forth the earlier and the present conceptions of Pellegrini-Stieda's disease. Not all foreign articles have been reviewed. A sufficient number have been read, however, to enable us to obtain an accurate idea of the European conception of the disease.

To explain the disease under consideration in this article, the following two hypotheses have been promulgated: A tendinous or ligamentous injury with interstitial



hematoma formation; chip fracture of the internal femoral condyle.

Some months after Stieda's original article, Vogel (3) published a work on "Typical Fracture of the Internal Epicondyle of the Femur." Since then Draudt, in 1911, has written "Fracture by Tearing of the Internal Epicondyle of the Femur," and Ishimoto and Kaneko have written "Fracture of the Internal Epicondyle of the Femur." These last two, in order to establish more firmly their conviction, presented drawings done after radiographs. In these they had traced opposite the osseous shadows a gap in the femur from whence the osseous fragments had become detached. A complete account of the operation for excision of the fragments was given with a description of the condylar wound.

According to Fredet (3), a fracture and calcification in the soft tissues are not mutually exclusive hypotheses. He presents pertinent evidence which militates against fracture origin by setting forth the following conditions, which must be satisfied before a diagnosis of fraction can be confirmed: First, when the shadow of Stieda appears on the radiograph done immediately or shortly after injury; second, when the osseous shadow presents a fracture aspect (quite different from the crescentic shape usually seen); third, when the radiograph shows on the condyle by means of a depression the relief of the fragments opposite; fourth, when such a depression, an osseous defect, is found at operation; fifth, when the osseous fragment, extirpated, presents the structure of normal bone.

However, in the ordinary rule, the appearance of the osseous mass is not contemporary with traumatism. A radiograph made at the moment of the accident or in the early days thereafter shows nothing. The mass ordinarily does not appear until the second week; thus, it cannot then be considered a fragment detached from the condyle at the moment of injury. This shadow is at first scarcely apparent and increases progressively in size. Histologic examination of osseous masses has shown

them to have all the characteristics of an ossification. Such were those described by Pellegrini in 1905, Vogel in 1908, Schüller, Weil, and others.

The consensus of opinion at present seems to disfavor the fracture hypothesis and incline to the opposite view. A review of our cases from the history, radiographic, and clinical evidence favors the calcification or ossification theory. We feel certain that fractures did not exist in any of them.

#### SUMMARY AND CONCLUSIONS

I. The history of the development of the syndrome is presented.

II. The etiology, pathology, diagnosis, treatment, and prognosis are considered.

1. The etiology is always traumatic—a blow on the internal condyle or torsion of the knee when flexed and adducted, constituting strain of the internal lateral ligament.
2. The pathologic process is essentially a myositis ossificans, though contrary opinions have been cited.
3. The diagnosis rests upon the history and the physical and x-ray findings. The x-ray findings at first are negative. Later, roentgenograms show the typical crescent-shaped shadow with the concavity directed toward the internal condyle of the femur, but separated from it by a clear space.
4. Treatment is conservative. In the early stages, diathermy and heat are valuable, but massage to the affected area itself is contra-indicated at all times. Immobilization for one or two weeks, followed by weight-bearing and active exercise, is the usual procedure. If

the mass interferes with motion, surgery is indicated.

5. The course is usually uneventful and the prognosis favorable, but it is important from a medico-legal standpoint.

### III. Five cases are reported.

Since the preparation of this article numerous papers have appeared in American Medical literature.

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## LOBITE TUBERCULOSIS

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THE term "lobite tuberculosis" was first applied by Leon Bernard (2-4-A), in 1923, to designate a type of pulmonary tuberculosis clinically not distinct from other forms of tuberculosis but definitely differentiated radiologically by a semi-diffuse shadow, involving the entire right superior lobe, with a lobar limitation very sharply defined at the fissure.

Sergent (12), who has also written on the subject, does not require a total lobar involvement for the diagnosis of lobitis. He considers the definite fissural demarcation as the most essential feature of the malady, and is little concerned whether the whole lobe or only a part of it is involved. Bernard is insistent on limiting the term to apply only to this condition as found in the right superior lobe. Most authors, however, believe that the same condition occurs in other lobes and employ the term lobitis for these as well, only prefixing the localizing modifiers; e.g., right superior. We believe with the opponents of Bernard that the term is applicable as well to cases in which the lobar involvement is total. These two points will become evident upon the presentation of our cases.

Among others who have written on the subject are principally Aris (1) and Bethoux (2), both of whom in 1924 dedicated their inaugural theses to it; Dufourt (7, 8), Cassaubon (5), Mendez (9), and Poix (11). Perhaps the most complete work is Leon Bernard's "Les debuts et les arrêts de la tuberculose pulmonaire," published in 1931 (4).

There is considerable bickering among the various authors whether lobitis or lobulitis is the proper term to denote this condition (6). It is, no doubt, an extensive patchy alveolitis, or tuberculous bronchopneumonia, and might well, therefore, deserve the name lobulitis, but be-

cause the striking feature is the lobar involvement, with its definite lobar limitation, and because the term lobitis is now well entrenched in the literature, we believe the present usage should be retained.

### INCIDENCE

Bernard gives no estimate of its frequency, but contents himself with stating that it is rather rare. Bethoux estimates the incidence at about 2 per cent of all pulmonary tuberculosis. Dufourt, from a study of over a thousand cases, gives the incidence as about 3.5 per cent. Malugani (cited by Mannucci, 10) contends that the frequency is 7 per cent. Mannucci (10), however, gives his figure as 4 per cent.

*Age and Sex.*—All authors agree that the greatest incidence is in young adults. Dufourt states that it is most common between the ages of 20 and 40 years; Aris, between the ages of 30 and 40 years, and Mannucci between 29 and 35 years. Badoineix and Denazelle (cited by Bethoux, 2) found three cases between the ages of 18 months and 15 years. All but Mannucci agree that it is more common in females.

*Location of the Lesion.*—Bernard, as previously mentioned, thinks lobitis occurs only in the right superior lobe. Most authors believe that right superior lobitis is the most frequent. Tocilescu (cited by Dufourt) thinks that it is found just as often in the left superior lobe. Of the 34 cases described by Aris, 22 were right superior, 8 were left superior, 2 were right inferior, 1 left inferior, and 1 right middle. Of Bethoux' 45 cases, 87 per cent were in the right superior lobe and 13 per cent in the left superior lobe. Dufourt found 32 cases in the right superior lobe and 3 in the left superior lobe. Malugani comes to the conclusion that 15 per cent of lobitis is in the inferior lobes.

Whether or not lobitis can be propagated

to or appear in a second lobe is a disputed point. To quote Casaubon, "Though delimited invariably by a fissure, lobitis does not always remain localized in one lobe; the tuberculous process may extend to the subjacent (unbounded lobitis or overpassed lobitis) or, better, to the opposite lung. In this latter case belongs our present patient."

#### ETIOLOGY

Concerning etiology most authors are relatively silent. Dufourt, however, from an examination of his 32 cases of right superior lobitis, found 9 cases which he thought represented recent, massive exogenous infections. Six other patients previously had symptoms leading one to suspect tuberculosis, as: insidiously developing anemia, loss of weight without apparent cause, dry pleurisy, slight hemoptysis. Whether the development of lobitis in these six cases represents an endogenous super-infection or not, he leaves for the reader to determine. In three of his cases there was an indefinite history of contact with tuberculosis suspects, and in the remaining 14 no exogenous or endogenous infective factors could be discovered. Three of the nine cases, which, from the history appeared to be exogenous infections, showed calcified nodules either in the same or the opposite lung, so the possibility of a recrudescence of the original infection must be considered.

#### COURSE AND SYMPTOMS

The onset of lobitis is most often indistinguishable from the ordinary, insidiously developing case of pulmonary tuberculosis; *i.e.*, there may be several of the following, anorexia, loss of weight, slight or moderate cough, etc., with or without expectoration, and perhaps an occasional streak of blood in the sputum. Bernard states that 75 per cent of the cases start in this manner.

Other cases are ushered in by a pseudo-influenzal or pneumonitic episode, while

still others are subacute in onset. But irrespective of the type of onset, the lesion is usually fully developed by the time x-ray examination is undertaken.

Also regardless of the beginning, there is usually little fever, and the expectoration is rarely profuse, or may even be *nil*, explaining the difficulty of bacteriological tests on the sputum. In rare cases the sputum is abundant and purulent. Whenever sputum permits of examination, the tubercle bacilli are found especially numerous when cavities exist.

*Signs.*—The physical signs, like the symptoms, are not peculiar to lobite tuberculosis. They, of course, vary in location with the lobe involved, but also vary within the lobe, *e.g.*, in the right superior lobe they are sometimes at the extreme summit, sometimes about the crest of the scapula, sometimes near the vertebral column, very often just above or below the clavicle. One would imagine that precise physical examination could detect the definite lobar limitation of the process, but as a matter of fact this has never been done. The signs are arbitrarily divided into three classes according to the stage of development of the process:

*Type A.*—A type of fibrous consolidation; exaggeration of whisper sounds; roughness of the respiratory sounds, sometimes gasping; dry and sonorous subcrepitant râles; sudden onset of coughing. This type can be observed primarily, or secondarily after a period of cracklings which are made to disappear by rest and treatment.

*Type B.*—This type appears when the lesions have become caseated and the classic cavitory signs are present. Very often some cracklings, sometimes dry, sometimes moist, are heard. According to Dufourt, these are the most frequent cases.

*Type C.*—The third symptomatologic type is produced by a complete lobar sclerosis. It is more or less of a cavitory type with localized and fixed sounds and the "growling noise described by Sabourin." Cavitory signs diminish, cavities become



dry, and fibrous transformation marks the last stage of clinical cure.

There is a possibility of a pseudo-cavitary type, owing to the deviation of the trachea because of fibrous traction. The rest of the lung and the opposite side almost invariably present no clinical signs. However, whatever the symptoms may be at the time of the examination of the lobite, the clinical examination is incapable of establishing the diagnosis, which appertains only to radiology. For this, the fluoroscope is often preferable to films because of the facility with which the bulb may be shifted and the rays brought in alignment with the plane of the interlobar fissure and the definite lobar limitation thereby demonstrated.

#### RADIOLOGIC EXAMINATION

Bernard divides lobitis into three radiologic types (cited by Dufourt, 7).

*Type 1, Homogeneous Type.*—The whole lobe is a dense, homogeneous shadow.

*Type 2, "Crumby" Type.*—Like the homogeneous type, but containing a series of clear spots which give it the appearance of scattered bread crumbs or of a honeycomb, corresponding to a patch of small cavities in the depths of the parenchyma.

*Type 3, Cavernous Type.*—Like the homogeneous type, but having a large cavity, often huge, and usually situated medially and below the clavicle.

Dufourt concluded that the pure homogeneous type is rather rare. Nevertheless, an arbitrary division of these three types seems to simplify the concept somewhat. Usually the shadow is more complex, resulting from a combination of these elementary aspects. Generally there is a veil stretched over the entire lobe from the juxta-scissural region, which is denser. This more or less homogeneous shadow is here and there reinforced by opaque streaks and nodules, and it is on this background that the breadcrumb-like flecks and cavity shadows are superimposed.

Frequent observations on many of Du-

fourt's patients have enabled him to draw the following conclusions concerning the development and course of lobite tuberculosis, both with and without active treatment. If the patient is observed in the early stage of lobitis, there will be seen simply a more or less uniform lobar infiltration, or what appears to be a consolidation about the interlobar fissure. Several weeks later the lobe may appear uniformly dense, and may show cavities, the interlobar fissure remaining well demarcated. In fact, this latter is the most striking feature in all stages. It is to be noted that in most cases the infiltration progresses through the lobe from the fissure, and that in many instances of superior lobitis, for example, the extreme summit seems to remain unaffected for a long time, which mode of development is strikingly in contrast to that of ordinary tuberculosis. At this stage the progress may become arrested, to be ultimately followed by fibrosis, or cavitation may ensue; even in this latter case, fibrosis ultimately occurs, usually with complete obliteration of the cavities.

The subsequent picture is determined by the contraction of the fibrotic parenchyma and the retraction of the lobe from the chest wall, influenced by the opposing forces exerted by the pleural adhesions. Except in very early cases, these adhesions are very common and are found most often about the fissure and the apex. If the external portion of the fissure is fixed by adhesion, the retraction of the lung modifies the fissure in one of two ways; either elevating and distorting it, or rendering it arciform, with the concavity downward.

In rare cases in which external adhesions do not exist, the fissure tends to become more and more vertical, approaching a plane almost parallel with the mediastinum in which no trace of previously existing cavities can be detected. In a minority of the cases the retraction of the lobe is less complete, and in it may be seen small negative shadows, relics of previous cavities.

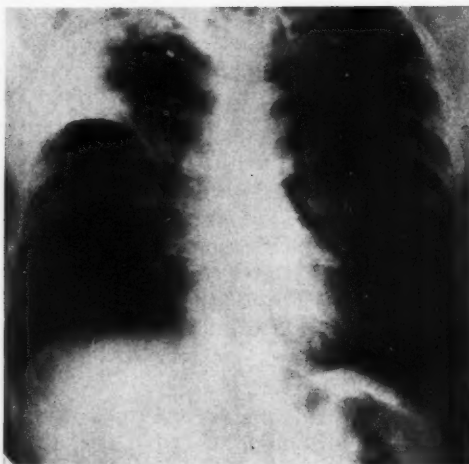


Fig. 1. Case 1. Right superior lobe rather opaque, with interlobular fissure well defined and a few aerated areas above fissure. (Roentgenogram made June 13, 1933.)

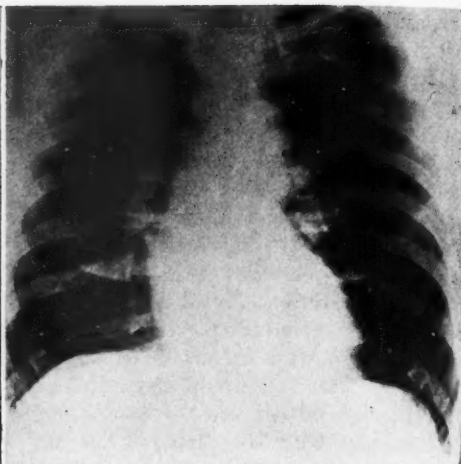


Fig. 2. Case 1. A few irregular densities in sub-clavicular region, showing a marked improvement in past four months. (Roentgenogram made Oct. 18, 1933.)

The institution of pneumothorax therapy produces two very different radiological pictures, according to whether the process is recent or rather old. In rather recent cases the lung detaches itself from the parietal pleura completely and the apex, being free from adhesions, descends. The sound lobes, being of normal consistency, retract more thoroughly and the lung then takes on a pyriform appearance. In cases that have existed for some time, the almost constant apical adhesions oppose a complete collapse and the affected lobe is incompletely retracted against the mediastinum, the apex remaining fixed. The frequently existing adhesions at the lateral extremity of the fissure are sometimes thick, permitting only a very incomplete collapse. Usually, however, they are thin, and, in general, it may be said that adhesions offer no obstacle to successful pneumothorax. Phrenicotomy seems to be much less effective than pneumothorax in bringing about collapse. Even in the completely developed case of lobitis a superficial examination and interpretation of the film could still lead one into error, for it is in the proximity of the fissure that the lesions predominate, and one must

sometimes gaze intently in order to convince one's self that the lobe presents some lesions which involve at least its greater part, if not the entire lobe. However, as previously stated, the extreme summit seems to remain long unaffected and this fact is, therefore, insufficient reason for regarding it as something other than lobitis. At times it is also very difficult to differentiate a lobitis from what the French call "periscissuritis." The sub-clavicular infiltrations seen in ordinary tuberculosis are differentiated by their being situated above the fissure and by the absence of the sharp fissural limitation.

#### PATHOLOGY

Because of the infrequency of lobitis, coupled with its rather benign nature, only a few autopsied cases of definitely determined lobitis have come to our attention. One of these, autopsied by Bethoux (cited by Casaubon, 5), was a case of right superior lobitis of the cavitory type. The lobe was of woody hardness, a dense fissure binding it firmly to the underlying lobe. Histologically, there were knotty lesions, surrounded by a fibrous network, and more

recent lesions and extensive patches of tuberculous bronchopneumonia containing tubercle bacilli. There was much interstitial sclerosis, with thickening of the blood vessels and bronchi. In this fibrous network, macrophages filled with carbon gave the typical appearance of anthracosis.

#### REPORT OF FOUR CASES

Case 1. J. E., male, age 37, weight 170 pounds, presented himself on June 13, 1933, after having had a fracture reduced under ether anesthesia. There was noticed a gradual loss of weight, accompanied by a slight afternoon rise of temperature, and the patient felt rather weak.

*History.*—A maternal aunt and a niece had died of tuberculosis, but the patient has never lived with a tuberculous suspect. Father living, has diabetes, age 70. There is no family history of cancer, cardiovascular or renal disease. Patient has a medical history of childhood diseases, pneumonia at the age of 15, and influenza at the age of 25. Patient complains of slight pleuritic pain at times.

*Physical Examination.*—Medium sized, muscular chest; left side better developed than right; respiration free on both sides; dry râles in right subclavicular region; left lung clear.

*Laboratory Examination.*—Wassermann negative; urine normal; repeated examinations of the sputum negative for the Koch bacillus; red blood count, 4,600,000; white blood count, 9,300; hemoglobin, 80 per cent.

*Radiologic Examination.*—Right superior lobe rather opaque, with interlobar fissure well defined and quite dense; a few aerated areas above the fissure (Fig. 1).

The second radiologic examination was made on Oct. 18, 1933. The patient had been at rest since the first observation and had gained 14 pounds in weight. At this time there were still a few occasional râles in the right upper chest. Radiologic examination of the right superior lobe showed a marked change in the interlobar fissure, which was almost transparent. There

were a few irregular densities in the subclavicular region. This film showed a marked improvement over the previous one. This was a case of the homogeneous type of lobitis (Fig. 2).

*Comment.*—The homogeneous radiological type of lobitis is probably the first stage of all varieties of the affection. This may subsequently progress to cavitation or fibrosis, or it may resolve, similar to the non-tuberculous pneumonias, as evidently happened in this case. This latter mode of termination seems not to have been previously mentioned. It was to be noted that there was a relative freedom from involvement of the extreme summit in both of these films.

Case 2. B. M., female, unmarried, age 19, weight 120 pounds, presented herself on Aug. 16, 1933. She complained of coughing for the last two months. She was hoarse and had sputum, which, however, was never blood-streaked, and she had a sore throat. She also complained of loss of weight and strength.

*Family and Environmental History.*—Parents and other members of the family, living and well. A young woman working in the same office with the patient, who was employed as an office worker, has since died of tuberculosis.

*Physical Examination.*—This revealed a pale, slightly undernourished young female. Nothing abnormal was found in the head or neck; inspection of the chest revealed nothing unusual. The heart was not enlarged; the sounds were good and there were no murmurs or arrhythmias. There were a few harsh râles in the right apex; the other lung-fields were negative.

*Laboratory Examination.*—Urine negative for sugar and albumin; Wassermann negative; sputum positive for tubercle bacilli.

*Radiologic Examination.*—Right superior lobe showed irregular opacities, with well-defined interlobar fissure (Fig. 3).

The second radiologic examination was made on Nov. 12, 1933, when her general condition appeared much improved; her cough had considerably subsided, and she

stated that she was feeling stronger and had made some gain in weight. The patient had been at rest since the previous

examination. No râles were noticed and the chest showed a decided improvement on the x-ray film (Fig. 4).

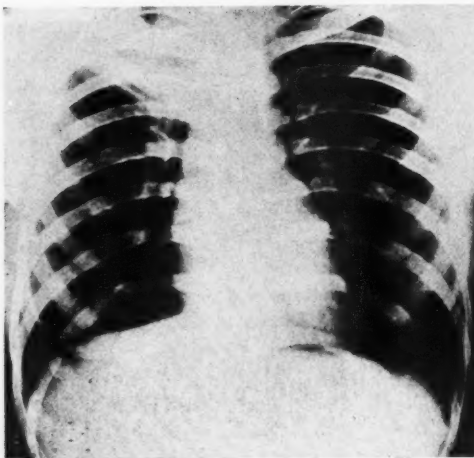


Fig. 3. Case 2. Right superior lobe shows irregular opacities, with well-defined interlobular fissure. (Roentgenogram made Aug. 16, 1933.)

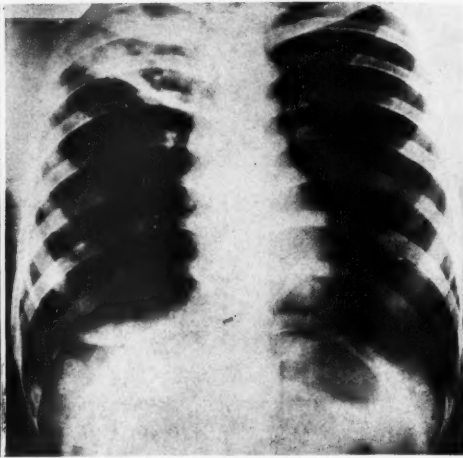


Fig. 4. Case 2. Three months later, right upper lobe seems to be improved. (Roentgenogram made Nov. 12, 1933.)

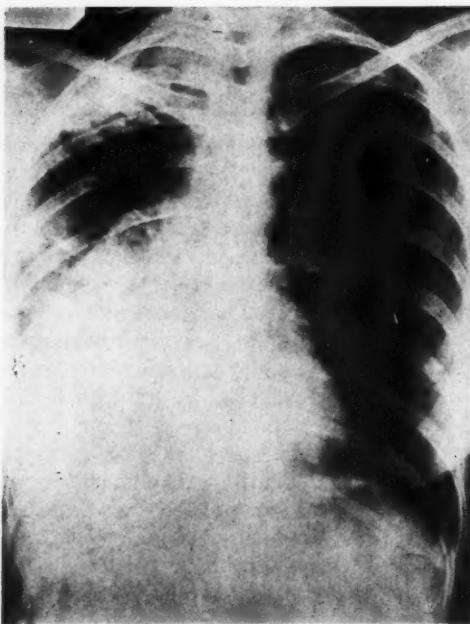


Fig. 5. Case 3. A number of dense infiltrations in the right apex. Right inferior lobe of almost uniform density, shadow stopping very abruptly at interlobular fissure. (Roentgenogram made Jan. 1, 1934.)

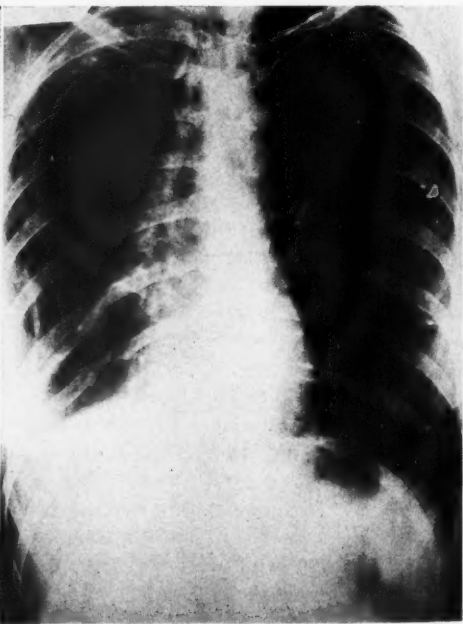


Fig. 6. Case 3. All structures of right lower half of chest retracted, including pleura. Right lower lobe shrunk, causing fissure to become more vertical. Large lucid area in center of lobe. (Roentgenogram made May 1, 1934.)



*Comment.*—Although the lung showed relics of childhood tuberculous infection, we are of the opinion that this was a case of exogenous infection, the source being in the tuberculous fellow office worker.

Bernard (Ref. 4-A) reproduces one of Tocilescu's roentgenograms which, except that it is a case of left superior lobitis, is very similar to our case, Figures 3 and 4. Bernard criticizes it on the basis of not having the fissure at the right place. He agrees with Bethoux that it is a case of false lobitis due to the pleuro-pulmonary sclerosis, following pleurisy. Bernard himself, however, gives a series of roentgenograms in which all but the first show the fissure at about the same position as in Tocilescu's case, except that it is on the right side. He is sure that his own case is lobitis and he says that the elevation of the fissure is due to fibrotic traction. He would, one might suspect, reject Tocilescu's case on the sole ground that it occurs in the left superior lobe. In this as well as in the previous case, the summit remained relatively clear.

Case 3. H. A., female, age 30, weight 108, college instructor.

*Past History.*—The usual childhood diseases; at the age of 24 she had long-continued slight elevation of temperature. At that time her doctor ordered her to bed for one month, after which he permitted her to resume her teaching, with the understanding that she rest as much as possible. Since then the patient has been quite well and has passed two life insurance examinations.

*Family History.*—The father died of heart disease; the mother, a brother, and two sisters are living and well. Present complaint: On Dec. 1, 1933, she noticed a pain in her right side which she says "felt like indigestion." She continued teaching until the Christmas recess, Dec. 23, 1933.

*Physical Examinations.*—This revealed a rather slight but healthy appearing young woman; examination of the head, neck, and abdomen was negative. The lower

right thorax was dull and a few constant coarse râles were present; the other lung-fields were clear.

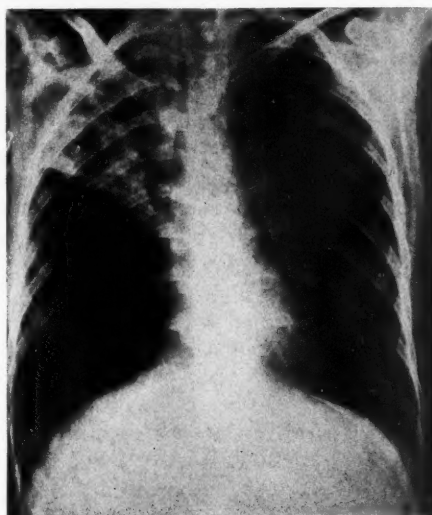


Fig. 7. Case 4. Right upper lobe uniformly dense, with diffuse fibrosis. Many small translucent areas throughout lobe. (Roentgenogram made May 4, 1934.)

*Radiologic Examinations.*—The first was made Jan. 1, 1934. There were a number of dense infiltrations in the right apex which were well defined. The right inferior lobe was of almost uniform density, the shadow stopping very abruptly at the well-defined interlobar fissure (Fig. 5). The second was made on May 1, 1934. The patient had been in bed since the previous examination. The right lower lobe at that time showed considerable retraction. The interlobar fissure was still well defined, but there was a large lucid area in the center of the lobe.

*Comment.*—Our second radiologic observation (Fig. 4) showed a noticeable reduction in the diameter of the entire right pleural cavity. The right lower lobe was considerably shrunk, and the fissure had become more vertical. These alterations were all signs of an extensive fibrosis.

Alterations in the right superior apex

were seen in both films, evidently due to the tuberculous infection at the age of 24. Whether or not the lobitis had its origin in the previous lesion could only be conjectured.

Case 4. Female, age 20, weight 110 pounds, student nurse.

*Past History.*—Had measles at age of 10; always healthy until about six weeks previous to examination on May 4, 1934. She had been running an irregular temperature for a short time, was hoarse, and expectorated sputum containing traces of blood. She thought she had lost about five pounds in weight.

*Family History.*—Parents, one brother, and two sisters living and well. The patient had been in training for 17 months, and did not remember of being definitely associated with anyone having tuberculosis.

*Physical Examination.*—Slender young female; heart of usual size; sounds normal, with no murmurs; chest negative with exception of a few very fine râles in right apex.

*Laboratory Examination.*—Urine negative; Wassermann negative; sputum contained tubercle bacilli.

*Radiologic Examination.*—Right upper lobe uniformly dense, with diffuse fibrosis; many small translucent areas throughout lobe.

*Comment.*—Lungs showed some evidence of previous infection, and the writer is of the opinion this is a case of endogenous infection.

#### SUMMARY

The points considered are summarized in the order of their discussion:

1. Lobitis is a form of chronic pulmonary tuberculosis involving one lobe more or less completely, and having as its most prominent feature sharp, fissural limitation.

2. It can be diagnosed only radiologically.

3. The incidence is between 1 and 7 per cent of all pulmonary tuberculosis.

4. Most cases occur between the ages of 20 and 40.

5. Infants and children are rarely attacked.

6. Females are more often attacked than males.

7. The right superior lobe is most commonly involved.

8. It is questionable whether lobitis spreads to other lobes.

9. It may be a recrudescence of an earlier tuberculosis, or a new exogenous infection.

10. The symptoms are usually the same as those of the ordinary incipient tuberculosis.

11. The sputum is usually small in amount, or absent.

12. Tubercle bacilli are always found when the sputum is abundant.

13. It starts insidiously in 75 per cent of the cases.

14. The physical signs are like those of ordinary tuberculosis, and the definite fissural limitation cannot be detected.

15. There are three ill-defined clinical types and three ill-defined radiologic types, depending on the stage of development or regression (consolidation, cavitation, and fibrosis).

16. Adhesions are usually present, especially at the lateral edge of the fissure and at the apex. They alter the shape and situation of the fissure and the lobe when fibrous contraction takes place, or when pneumothorax is resorted to.

17. Four cases were presented; in three of them the lobitis was in the right superior lobe, and in one in the right inferior lobe.

I wish to thank Dr. H. A. Schulz whose clinical study of these cases was of great value.

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# SCATTERED RADIATION IN ROENTGENOGRAPHY OF THE CHEST<sup>1</sup>

PRELIMINARY REPORT

By R. B. WILSEY, M.A., *Rochester, New York*

SINCE the Potter-Bucky diaphragm was developed into practical form by Dr. Potter in 1917, the suggestion has occasionally been made that it be adapted to roentgenography of the chest. Probably the chief reason why this has not been done is doubt as to whether the degree of roentgen-ray scattering in the chest is sufficient to justify the use of the Potter-Bucky diaphragm. An additional reason, perhaps, has been the technical difficulty of adapting the Potter-Bucky diaphragm to the special conditions of chest roentgenography, such as the short exposure times and the rapid stereoscopic shift of the cassettes. The technical difficulties can doubtless be overcome, provided it can be shown that there is any real advantage in the use of the Potter-Bucky diaphragm in roentgenography of the chest.

This question is being studied by the following methods: (1) measurement of the proportions of scattered radiation reaching the film in chest roentgenography; (2) experiments with suitable phantoms to measure the effect of the Potter-Bucky diaphragm upon roentgenographic contrast, and (3) experimental roentgenography of the human chest with the Potter-Bucky diaphragm.

With these methods, it must be remembered that contrast can be increased by lowering the roentgen tube voltage as well as by the use of the Potter-Bucky diaphragm. In either case, the exposure in terms of the load applied to the roentgen tube is increased, and the essential question is whether, with equal load on the roentgen tube, greater contrast and detail are given by the use of the Potter-Bucky diaphragm than without it.

To measure the proportion of scattered radiation reaching the film in the roent-

genography of human chests, a group of lead shot, each about 4 mm. in diameter, and mounted 2.5 cm. apart on a sheet of cardboard, were supported on the patient's back. The shadow of each shot on the film was thereby protected from the primary radiation of the focal spot, but recorded the scattered radiation from the patient. Density readings were made of the shot shadow on the film and of the surrounding area which was affected by both scattered and primary radiation. These density values were converted into relative roentgen-ray intensity values by means of calibration series of known exposures impressed upon the corners of the film. Both the calibration areas and the roentgenographic image received the same development. With this procedure, the resulting data on ratio of scattered to total radiation were independent of variations in either exposure or development.

Observations made on a group of normal adult chests of medium size showed that on the average, about 55 per cent of the radiation reaching the film was scattered radiation. Less than half the radiation is employed in forming the roentgenographic image; the rest merely produces a general fogging effect. The proportion of scattered radiation is not uniform in all portions of the chest roentgenogram. In the group of normal, medium sized chests scattered radiation in the shadows of the apices averaged about 50 per cent. The proportion of scattered radiation was highest in the outer borders of the lung area, where it averaged around 65 per cent. Outside the apices and the outer borders of the lungs, the proportion of scattered radiation was found to depend largely on tissue density, varying from about 40 per cent in areas where there were few lung markings to 60 per cent in areas of greater concentration of lung tissues.

<sup>1</sup> Presented before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.



Most pathological conditions in the lungs involve an increase of tissue density, and in observations upon patients showing lung pathology, the higher proportions of scattered radiation were observed in areas showing increased masses of diseased tissue. For instance, in a patient with a large chest (28 cm. thick) suffering from anthracosis, the average proportion of scattered radiation was 66 per cent, with many areas ranging between 70 and 80 per cent. The degree of roentgen-ray scattering will doubtless be found even greater in cases of fluid or solid masses in the lungs.

The type and extent of lung pathology vary so greatly that it is impossible to formulate any general rules regarding the proportion of scattered radiation occurring in the roentgenography of pathologic areas. In any case it is apparent that the problem of scattered radiation must be seriously considered in our efforts to improve the methods of chest roentgenography.

The effectiveness of the Potter-Bucky diaphragm in chest roentgenography was investigated first by means of a phantom constructed to approximate the essential conditions of the scattering of roentgen rays in the human chest. A rectangular hollow box was made of masonite prestwood, a compressed fiber board having a specific gravity just perceptibly greater than that of water, and composed largely of the same chemical elements as comprise the soft tissues of the human body. The dimensions approximate roughly those of the human chest and the thicknesses of the walls were adjusted by trial to produce the same proportion of scattered radiation (about 55 per cent) as occurs in the normal adult chest of average size.

A test object for the measurement of contrast was prepared by drilling two holes near the middle of the central layer of the phantom, and mounting small blocks of prestwood next to each hole. Several lead shot were also mounted on the back of the phantom, toward the roentgen tube, for measurement of scattered radiation. Measurements of the contrast and propor-

tion of scattered radiation were made at various kilovoltages, both with and without the use of the Potter-Bucky diaphragm.

A special model of Potter-Bucky diaphragm was made up for these experiments by the Liebel-Flarsheim Company. The grid had a slit ratio of 1 to 8, and the lead strips were spaced  $\frac{1}{32}$  inch apart. The grid itself was  $\frac{1}{4}$  inch thick. The mechanism actuating the grid was constructed to permit a rapid travel of the grid for the short exposures necessary in chest roentgenography. Electric contacts on the frame of the grid were connected with the relay switch of the x-ray machine so that the movement of the grid timed the exposure. The speed of the grid could be adjusted by the turn of a knob to give exposures ranging from  $\frac{1}{5}$  to  $\frac{1}{20}$  second. This apparatus was especially suited for testing the value of the Potter-Bucky diaphragm under the special conditions of chest roentgenography.

Experiments were carried out with the chest phantom to determine the effect of the Potter-Bucky diaphragm upon roentgenographic contrast. The exposures were made at tube voltages ranging from 40 to 100 kilovolts on a valve rectified roentgen machine. The contrast obtained with the Potter-Bucky diaphragm was materially higher than that without the diaphragm. At 70 kilovolts, for instance, the Potter-Bucky diaphragm increased contrast by 56 per cent. Furthermore, the data show that the contrast with the Potter-Bucky diaphragm at 100 kilovolts is slightly higher than the contrast without the diaphragm at 40 kilovolts.

The Potter-Bucky diaphragm is thus more effective than a decrease in kilovoltage in improving contrast, and does so with less increase in the load on the roentgen tube. With this phantom the Potter-Bucky diaphragm increased the exposure required to about double the normal exposure without the diaphragm, whereas a reduction of tube voltage from 100 to 40 kilovolts required an increase in the energy applied to the tube to about five times the original value.

Another fact shown by these data is that with the Potter-Bucky diaphragm, a change in tube voltage affects contrast to a greater degree than is the case without the diaphragm. In passing from 100 to 40 kilovolts the increase in contrast was found to be 44 per cent greater with the Potter-Bucky than without it. Tube voltage influences contrast only in the primary image forming rays; since scattered radiation tends to mask the influence of other factors on the primary roentgen-ray image, the removal of scattered radiation should materially increase the influence of tube voltage upon image contrast.

In testing the value of the Potter-Bucky diaphragm in the roentgenography of human chests, effort should be made to avoid any increase of load on the roentgen tube, in order to avoid the necessity of increasing focal spot size or exposure time, as either of these changes has an adverse effect upon sharpness of outline.

It is possible to compensate for the increased exposure required by the Bucky diaphragm, without increase of load on the roentgen tube, by the following method. The tube voltage is increased, and the tube current proportionately decreased, until the increased roentgen-ray output is sufficient to make up for the scattered radiation removed by the Potter-Bucky diaphragm. In a typical case, it was found that a good exposure of a patient could be made without the Potter-Bucky diaphragm at 50 K.V.P., 500 ma., 500 foot target-film distance, in  $\frac{1}{20}$  second.

With the introduction of the Potter-Bucky diaphragm, a roentgenogram of similar density could be made at 70 K.V.P., 350 ma., with the other conditions unchanged. By this procedure the use of the Potter-Bucky diaphragm does not involve an appreciable loss in sharpness, as neither the focal spot size nor exposure time has to be increased. When the increase of roentgen-ray exposure required by the Potter-Bucky diaphragm was compensated for in this way, the diaphragm was found to give appreciably better contrast than the technic without the diaphragm in the

case of the normal chest of average size, and the advantage of the diaphragm increased with increase in the mass of tissue to be penetrated arising either from larger size of patient or from pathologic causes.

With the chest phantom, the Potter-Bucky diaphragm was able to increase contrast by 40 per cent without necessitating any increase of load applied to the x-ray tube.

The Potter-Bucky diaphragm, therefore, offers a moderate, but definite advantage in roentgenography of the chest without requiring increased load on the x-ray tube or greater power of the roentgen machine. It produces a net gain in contrast without appreciable loss of sharpness.

In chest roentgenography with the Potter-Bucky diaphragm, tube voltages as low as 70 kilovolts give about as high contrast as is desirable in a view of the *whole chest*. However, if the principal pathology present is confined to some local area, it may be advantageous to secure higher contrast in this particular area, sacrificing detail in other portions of the chest. In such a case, the combined use of the Potter-Bucky diaphragm and low kilovoltage makes it possible to secure a degree of contrast that is not attainable by any other method.

Lowering the kilovoltage alone improves contrast *least* in those areas of the chest where the proportion of scattered radiation is highest; whereas the Potter-Bucky diaphragm has its *greatest* effect in these areas. Thus the Potter-Bucky diaphragm changes the quality of the roentgenogram; while it increases contrast in all portions of the roentgenogram, it increases contrast most in areas with the greatest proportion of scattered radiation, and thereby increases detail most in portions of the roentgenogram most difficult to improve by other methods. The Potter-Bucky diaphragm should be particularly valuable in the roentgenography of the types of chest which ordinarily give poor contrast, such as those of large and fleshy patients.

During these experiments, an opportunity was presented of making some chest roentgenograms combining the use of the

Potter-Bucky diaphragm and the rotating target roentgen tube. These roentgenograms showed both more contrast and sharper definition than those made with a stationary target, without the Potter-Bucky diaphragm, even though the latter were made at lower kilovoltages, higher milliamperages, longer target-film distances, and shorter exposure times.

In other words, the removal of scattered radiation, and the reduction in size of focal spot were more effective in increasing contrast and sharpness in the chest roentgenogram than the use of a longer target-film distance, lower kilovoltage, and shorter exposure time.

#### SUMMARY

In the roentgenography of the normal adult chest of medium size, the proportion of scattered radiation reaching the film averages nearly 55 per cent. The propor-

tion varies in different areas from about 40 per cent to 60 or more per cent, the higher values occurring in areas where the lung tissues are most dense and near the periphery of the lungs. In roentgenography of such a chest, the use of the Potter-Bucky diaphragm increases contrast materially. The Potter-Bucky diaphragm may be used in chest roentgenography without loss of sharpness due to increased tube load or exposure time, provided the tube voltage is suitably increased and the tube current proportionately decreased. Under these conditions, the Potter-Bucky diaphragm produces a moderate, but definite advantage in the roentgenography of the average chest, and this advantage increases with the increase in the mass of tissue to be penetrated arising either from a larger size of patient or from pathologic conditions in the chest.

# THE VALUE OF BREAST RADIOGRAPHY<sup>1</sup>

By IRA H. LOCKWOOD, M.D., *Kansas City, Missouri*



ON a properly executed roentgenogram of the breast it is important that the rays strike the breast in an exactly transverse position, otherwise there will be superimposition of the roentgenographic image. In the flaccid or pendulous breast, Seabold (17) has constructed a cradle that has proven satisfactory. In our own work we have used a rectangular compression bag capable of being filled with air after it has been placed under the patient. The technic of the examination has been described in detail in previous reports (11, 12); since then certain changes have seemed advisable. We are now using 36-inch distance, kilovoltage varying from 55 to 70, 100 ma., with an exposure of 0.3 to 1 second with the Potter-Bucky diaphragm. By using the above factors there is no distortion of the breast structure and the time is sufficiently short to eliminate movement. Several negatives using different exposures may be necessary to establish a clear concept, and the value of serial study in the diagnosis of certain conditions cannot be overestimated (7).

The roentgenogram of the normal breast shows the following four distinct anatomic zones of different densities (8): (1) The cutaneous zone, with confirmation of the nipple and skin margin in profile; (2) the adipose zone of varying degrees of thickness and showing the fibro-glandular prolongations from the mammary mass to the skin; (3) the glandular zone, with the structures appearing as a pyramid, limited at the back by the retro-glandular zone, with some irregularity of the anterior margin, especially in the region of the nipple, due to the formation of milk ducts; (4) the retro-glandular zone appearing as a smooth, narrow, clear space separating the base of the breast from the pectoral

muscles. Two distinct histologic patterns of the glandular zone have been described (4): mazoplasia and cystiphorous desquamative epithelial hyperplasia. Mazoplasia is the term given to the type of desquamation of epithelial cells in the terminal ducts and their acini, accompanied by hyperplasia of the pericanalicular and periacinous connective tissue, and often with the formation of ducts and acini. On the roentgenogram this state is characterized by a frond-like appearance of the parenchyma with the converging striations forming a fine indistinct band beneath the nipple, and a varying amount of non-opaque stroma between the mass of the gland and the derma.

Cystiphorous desquamative epithelial hyperplasia begins as a desquamative epithelial hyperplasia that ends in the formation of cysts; these breasts are often "shotty" to palpation and correspond to the state of chronic cystic mastitis. On the roentgenogram the fibro-glandular striations are marked, the parenchyma appears to fill all the available space to the derma, and there is a broad dense band beneath the nipple. It is in these breasts that both large and small cysts are found.

Between these two extremes are breasts showing characteristics of each type. Whether one accepts Cheatle's or Handley's (9) explanation of the histologic changes accompanying these different states, each presents a typical appearance on the roentgenogram.

Pathologic processes, either inflammatory or neoplastic, are shown on the roentgenogram by alterations in contour or changes in density of the anatomic zones of the breast. Through the courtesy of Dr. J. M. Wainwright, microscopic sections of the whole breast have been made showing the alterations in contour and outline of the different zones of the breast.

<sup>1</sup> Read before the American Congress of Radiology at Chicago, Sept. 25-30, 1933.



and also the changes in density with a correlation of the microscopic and roentgenographic findings.

#### CYSTS

Cysts are associated with the state of cystiphorous desquamative epithelial hy-

perplasia were present in the right breast, with numerous small clear areas characteristic of cysts.

*Histology.*—There was diffuse polycystic mastitis.

After the menopause, the roentgenogram shows varying degrees of atrophy of

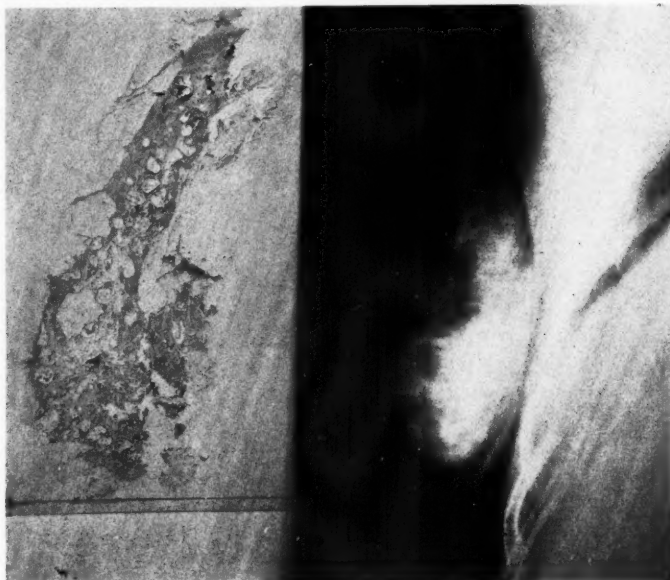


Fig. 1. Case 1. Numerous small clear areas characteristic of cysts. Histology: diffuse polycystic mastitis.

perplasia. The roentgen findings are characteristic; they appear as smooth, relatively clear, areas in the parenchyma of the gland. If a cyst arises in a localized area of the cystiphorous state, it may present the appearance of a faint solid tumor without the dense, well-defined outline (13). A cyst containing fluid is relatively less dense than a solid tumor (18).

Case 1. Mrs. W., aged 49 years, had had an intermittent bloody discharge from the right nipple for 2 years. A lump was first noticed in the breast one year before examination. There had been marked enlargement during the previous month, pain beginning one week later.

*Roentgen Examination.*—The signs of cystiphorous desquamative epithelial hy-

perplasia were present in the right breast, with numerous small clear areas characteristic of cysts. The glandular structure, with an increase in the amount of non-opaque stroma and a reduction in the fibrous striations. This replacement is far more complete in mazoplasia than in chronic cystic mastitis; the irregularity of the glandular atrophy may lead to soft mottled shadows representing residual lactating acini (15), or senile parenchymatous hypertrophy (3). The glandular atrophy permits greater density of the cystic lesion than the surrounding stroma.

#### SOLID BENIGN TUMORS

Solid benign tumors appear on the roentgenogram as circumscribed opaque areas, often multiple with a dense periphery

but no evidence of invasion of the adjacent tissue. There may be distortion but no interruption of the striations; there is no axillary extension and no evidence of cystiphorous changes.

hyperplasia; this, with the bleeding from the nipple, warrants a presumptive diagnosis of papilloma in the absence of a mass, or a roentgenologically demonstrable tumor.



Fig. 2. Case 2. Infiltrating mass characteristic of malignancy. Histology: large areas of anaplastic epithelium.

#### PAPILLOMA

There are no characteristic roentgen findings to identify these microscopic lesions. The significance of a serohemorrhagic or a hemorrhagic discharge from the nipple is a moot point. Bloodgood (2) is of the opinion that it more often accompanies a benign rather than a malignant lesion. Deaver and McFarland (6) state that a bloody discharge in a majority of cases is due to papillary growths. Adair (1) says a dark bloody discharge always means a duct carcinoma. The consensus of opinion seems to be that discharge from the nipple cannot be regarded as of great significance in differential diagnoses (14). One finds on the roentgenogram evidence of cystiphorous desquamative epithelial

#### FIBROSIS

The roentgen appearance of fibrosis of the breast is often not as confusing as the clinical; one sees on the negatives, except in the cases of local trauma (5), many faint irregular masses of scar tissue involving both breasts, with fine striations extending into the axilla, but no abnormalities in the contour of the anatomic zones.

#### CARCINOMA

The roentgen identification of early carcinoma in the presence of chronic cystic mastitis before the menopause may be difficult; however, the majority of individuals who come for an examination with the history of a lump in the breast are

encountered after the age of forty (10), when the involutional changes are such that the neoplastic characteristics are easily identified. Multiple tumors are not necessarily benign; clinically, they may be

Case 2. Mrs. R., aged 70 years, first noticed a lump in her left breast two years previous to examination. Shortly thereafter, it began to enlarge. She has had some pain and discomfort.

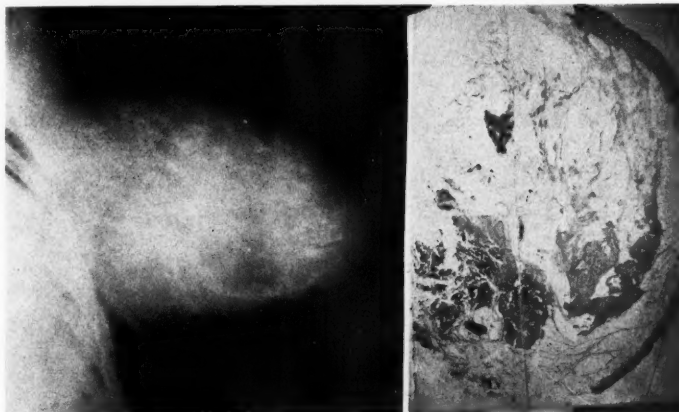


Fig. 3. Case 3. Infiltration characteristic of the spread of carcinoma along the connective tissue septa. Histology: mixture of scirrhous and medullary carcinoma.

appreciated by palpation as separate and distinct multiple nodules. Attention has been called to the importance of distant secondary malignancy (19) in many cases in which the disease seemed to be confined to a single nodule; microscopic sections of the whole breast revealed the frequent presence of impalpable axillary glands and involvement of the lymph structures along the pectoral muscles.

On the roentgenogram, one sees the following alterations in contour and density of one or more of the anatomic zones: the tumor appears rather dense and irregular, with interruption of the striations; the periphery may be feathery or more compact than the mass giving a false sense of encapsulation due to the compression of the surrounding tissues; extension into the lymph nodes in the axilla appears as smooth, dense, opaque areas, while the inflammatory nodes are faint and irregular in outline.

*Roentgen Findings.*—Marked involutional changes; irregularity of the anatomic zones; thickening of the skin; an infiltrating tumor mass in the left breast characteristic of malignancy.

*Histology.*—There was a fibrous tissue stroma with large masses of anaplastic epithelium (carcinoma).

✓ Case 3. Mrs. J., aged 44 years, noticed a lump in the left breast with a dark angry area about the nipple a month before examination.

*Roentgen Findings.*—A marked infiltration of the entire left breast radiating from a dense mass, characteristic of a spread of carcinoma along the connective tissue septa. There was axillary involvement.

*Histology.*—The entire glandular tissue was infiltrated, unusually shotty, and indurated. There was a mixture of scirrhous and medullary carcinoma.

Case 4. Mrs. M., aged 52 years, noticed a lump in the left breast one year

before examination. Six weeks later, the skin over this area became red and infiltrated.

*Roentgen Findings.*—An irregularity in contour of the anatomic zones of the left

cystic mastitis. Roentgenograms may establish the following: the presence or absence of a mass, often before the disease is clinically apparent; define its mammary or axillary extensions; reveal both benign and

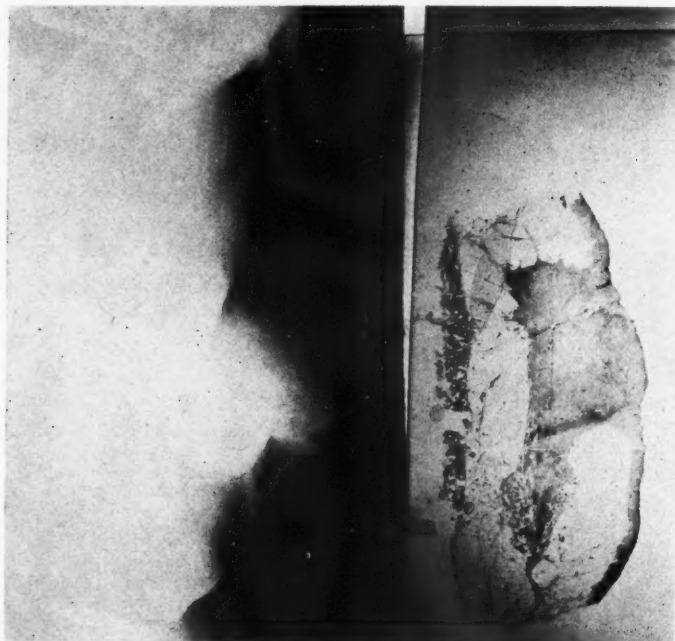


Fig. 4. Case 4. An infiltrating mass extending from beneath the nipple back to the retro-glandular zone. Histology: anaplastic cells with numerous mitotic figures.

breast, with an infiltrating mass extending from beneath the nipple back to the retro-glandular zone. There was axillary node involvement.

*Histology.*—There was more than one tumor and, microscopically, the tissue appeared quite different. There were anaplastic cells with numerous mitotic figures.

The value of breast radiography is shown by the high percentage of diagnostic accuracy in the differentiation of benign from malignant lesions (20), and is exceeded only by the microscopic examination of excised tissue. The limitations (14) of this method are: the inability to recognize microscopic areas of cancer; early malignant degeneration in benign tumors, and early carcinoma associated with chronic

neoplastic changes and the transition of a benign into a malignant lesion; depict those changes characteristic of the spread of carcinoma along the connective tissue septa—dangerous because the cells permeate along these septa—reach the more active lymph streams, and are easily carried to distant parts; offer a permanent record of the findings; be a means of serial study of the changes in the breast; offer none of the physical limitations of transillumination, and in those cases positive for carcinoma the need for biopsy can be eliminated.

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## FURTHER OBSERVATIONS ON THE ROENTGEN EXAMINATION OF THE AORTA<sup>1</sup>

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THE purpose of this presentation is mainly to revive the interest of roentgenologists in the roentgen study of the aorta. It seems that, of late, many roentgenologists have become apathetic toward this subject—a strange circumstance in view of the history of this examination.

At first, the cardiologists were reluctant to accept the contributions of the roentgenologists. But as they grew more familiar with the method, and realized its advantages and superiority over the older methods for the demonstration of dilatation and aneurysm of the aorta, their interest in it increased. Now, with one accord, the cardiologists have adopted and endorsed it. They were quick to take advantage of a method that would demonstrate between 10 (1) and 30 (2) per cent of aneurysms not detected by other means.

Levine (1), in discussing the diagnosis of aneurysm of the aorta, states: "There remained a few, however, in whom the aneurysm produced no physical signs that were detectable and no particularly characteristic symptoms. Here the x-ray examination was practically the only means of detecting the underlying condition. A more liberal use of x-ray and fluoroscopy of the aorta and a more careful roentgenologic interpretation of these findings, would certainly enable us to detect some cases of aneurysm of the aorta that would otherwise be overlooked." White (3) and many other cardiologists express similar views.

Roentgenologists are, therefore, obli-

gated to take an active interest in this subject, to realize their responsibilities, and to make still further contributions.

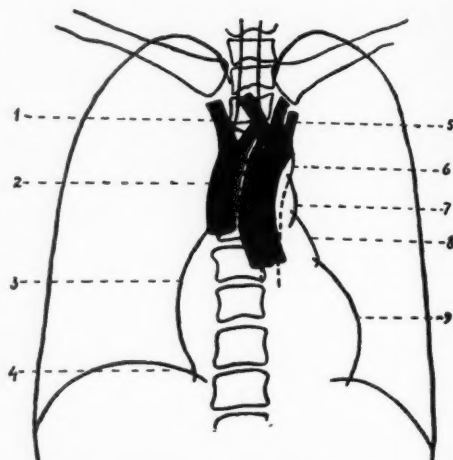


Fig. 1. Model sketch showing the normal relation existing between the structures comprising the cardiac and supracardiac shadows in the normal adult sthenic type: 1. Right innominate vein. 2. Superior vena cava. 3. Right auricle. 4. Inferior vena cava. 5. Left subclavian artery. 6. Descending aorta. 7. Pulmonary artery. 8. Left auricle. 9. Left ventricle.

### THE NORMAL AORTA

The normal relations of the aorta in the frontal view are illustrated in Figure 1. This was based on anatomic studies (4) with injections of barium emulsion and air into the aorta and superior vena cava. When senile changes occur, beginning about the fifth decade, the right border of the aorta tends to override the vena cava and to approach its right margin.

These relations are also influenced by the character of the aortic arch. The limbs of the arch may be closely approximated, widely separated, or rotated at various angles about the central axis of the body, depending partly on the form and course

<sup>1</sup> Read before the Radiological Society of North America, at the Seventeenth Annual Meeting, at St. Louis, Nov. 30-Dec. 4, 1931.

<sup>2</sup> I wish to express my gratitude to Mr. Robert Stoltz, of the General Electric Co., of Kansas City, for his construction of the rotating platform and his assistance in obtaining normal roentgenograms, and to Mr. Bernard M. Welch for his valuable technical aid and indefatigable efforts in obtaining normal subjects.

taken during the embryologic period of development, but, to a greater extent, on the level of the diaphragm. In the hypersthenic type in which the diaphragm is high, the limbs of the arch are spread apart. In the hyposthenic type, with low diaphragm, the converse obtains. Between these two extremes, are various gradations.

In passing, I wish to call attention to the difference in distensibility of the aorta of a young adult, aged 34 years, and that of a much older individual, aged 68 years. Note the greater distention of the senile aorta with practically the same air pressure as that employed in the aorta of the young adult. The sclerotic aorta that has lost its elastic tissue is more relaxed and does not offer as much resistance as the aorta with good elastic tissue. These facts should be borne in mind when considering the changes in the aorta at different age periods and in various stages of disease involvement.

It will be recalled that the normal aortic arch does not assume a direct course from right to left in the coronal plane, but is directed anteroposteriorly in a slightly oblique plane (Fig. 2). Hence, methods based on the oblique position are likely to give more accurate information concerning the aortic arch. Chaperon (5) found that the aortic arch was best observed and measured at an angle of  $25^\circ$  in the left anterior oblique position.

*Technic.*—A graduated rotating platform (Figs. 3-6) will be found very useful in obtaining the correct position. With this device, accurate comparative periodic observations and measurements can be made.

Direct the patient to stand erect on the platform and parallel to the plate changer. His body should be from 2 to 3 inches from the latter. Instruct the patient to make no movements whatever until he is directed. Release the lock and rotate the platform, clockwise, by hand until the indicator reads  $25^\circ$ . Grasp both shoulders of the patient and carefully incline him forward in a parallel direction until the left shoulder meets the plate changer. Adjust

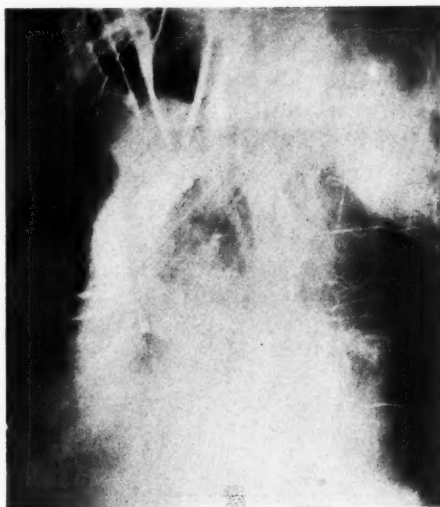


Fig. 2. Left anterior oblique position, demonstrating the entire aortic arch filled with barium emulsion.

the shoulder rest seen at the upper right in Figure 5.

The exposure technic factors are: 4 ft. distance, 100 ma.,  $\frac{1}{5}$  second, kilovoltage—average size patient, 90 KV., moderately stout, from 93 to 95, and very stout, 98. All exposures are made with respiration suspended in the inspiratory phase.

The roentgenogram obtained with this technic must have sufficient density to show distinctly the ascending and descending outer borders of the arch, and the trachea with its bifurcation. Normally, the trachea is located outside of the right border of the spine and from 3 to 8 mm. from it.

*Description.*—The outer ascending and descending borders of the arch may assume a variety of forms. The ascending border may be slightly convex, straight vertical, straight oblique, or a combination of these forms. In addition to all the above forms, the descending border may be slightly concave. Moreover, the descending border, normally, before the fifth decade, does not surpass the right margin of the spine, *i.e.*, a line joining the spinous processes.

With the senile sclerotic changes occurring about the fifth decade, the aorta increases in density, and the outer borders of

at the same time, the tube is distended. The application of these facts to the study of the aorta is obvious.

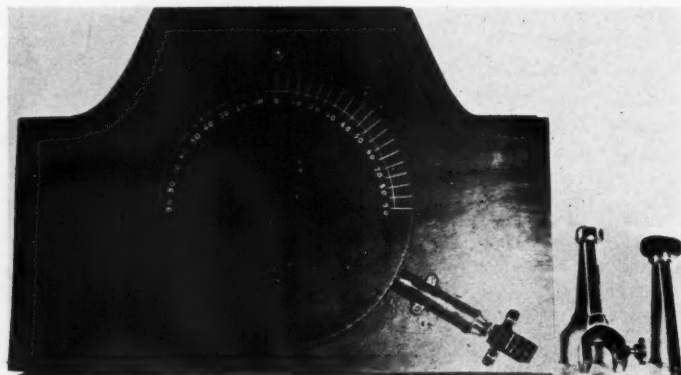


Fig. 3. Platform for making oblique roentgenograms with upper surface graduated in degrees. The upper part is pivoted in the center and rotates on four ball bearings. A simple door-stop brake device is located at the side.

the arch become more convex, elongated, and tortuous. This is the senile type of uncoiling.

It will be noted that all observations and measurements relate to the outer borders of the arch, which are plainly visible, while the others are not. I am unable with the present technic to visualize the latter before the period in which senile changes take place. However, until a technic is obtained which will enable us to see all borders of the arch, we must depend on indirect methods.

In this connection, it is interesting to speculate concerning the possibilities of observing the anterior and posterior borders of the individual limbs with the use of 1,000 milliamperes technic and a constantly moving Bucky diaphragm.

It is obvious from a study of simple tube mechanics that the outside measurements of a coil will indirectly indicate the caliber of the individual limbs. Figure 8 illustrates the changes that take place in an ordinary rubber tube subjected to air pressure, when both ends have been previously fixed in position. As the pressure is increased, the limbs of the coil tend to separate and the arch becomes elongated;

Roentgenographic and fluoroscopic observations of the heart and aorta should be made in all positions. Moreover, at the risk of stating a platitude, the roentgen observations should always be correlated with the history, physical findings, and the data obtained from other clinical methods of investigation.

#### THE PATHOLOGIC AORTA

Having established the technic for examination of the aorta, and appreciating the manifold character of its normal contours, we are in a position to study the pathologic changes to which it may be subjected. For our purposes, there are two major disturbances that may occur, namely, aneurysm and dilatation.

I shall not enter here into a discussion concerning the differential diagnosis between aneurysm and the conditions which may simulate it. A careful study of the roentgenograms in all positions, together with the roentgenoscopic observations, will, with few exceptions, readily establish the eccentric, sharply outlined, fusiform or sacculated protuberance of the aorta.

Levine (1) states, "The discovery of a



definite aneurysm of the aorta, as distinguished from a slight dilatation of the aorta so frequent in hypertension, should

widely separated limbs, exaggerated convex borders, and displacement of the descending border beyond the shadow of the

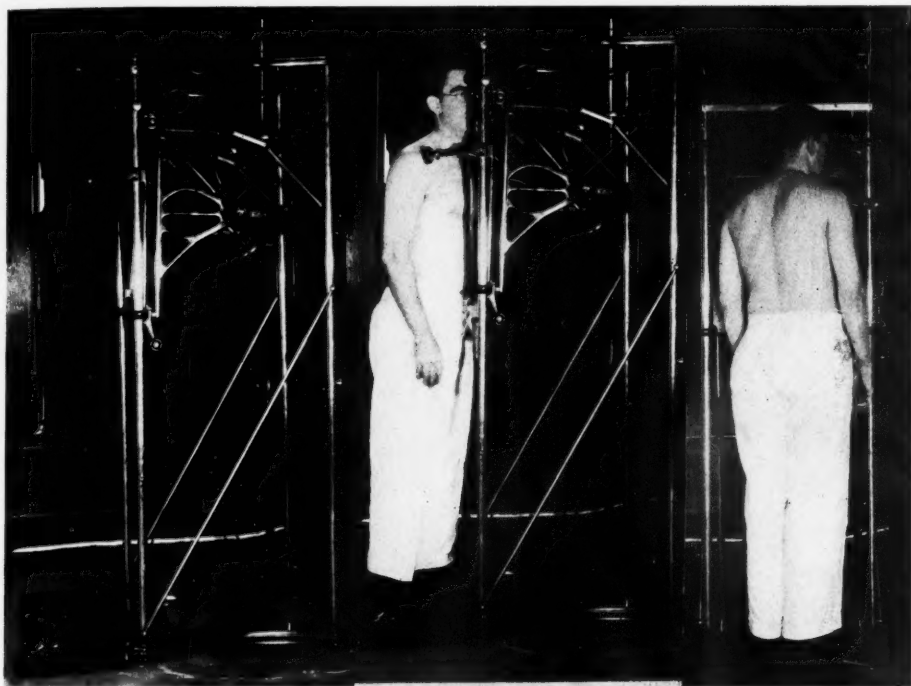


Fig. 4 (left). Platform in position ready for use.<sup>3</sup>

Fig. 5 (center). Side view showing patient in left anterior oblique position, 25°, with adjustable rest applied to right shoulder.

Fig. 6 (right). Direct view of same.

be considered as positive evidence of syphilis." This view is shared by most authorities, but Kaufmann (6) investigated 24 aneurysms of the aorta and found "an equal number due to arteriosclerosis and syphilis." However, he makes the further comment that they all occurred in very elderly individuals. Aneurysm of the aorta may be associated either with an enlarged left ventricle or one of normal size, depending on the degree of involvement of the aortic valves. This will be discussed in more detail later, under the subject of dilatation and aortic regurgitation.

The detection of a dilated aorta, with its

spine, becomes an easy task after the facts concerning the normal aorta have been grasped. But the explanation of this dilatation in a particular case is a much more difficult problem.

Three conditions are in the main associated with dilatation of the aorta, namely, syphilis, hypertension, and arteriosclerosis (Fig. 9). They may exist singly or in combination, *viz.*, syphilis plus hypertension, syphilis plus arteriosclerosis, syphilis plus hypertension plus arteriosclerosis, and hypertension plus arteriosclerosis (Fig. 10). All three conditions may be accompanied by an enlarged left ventricle.

The dilated syphilitic and hypertensive aortas, seen in the third and fourth decades, will present a smooth curve. But,

<sup>3</sup> The base of the plate changer should be elevated about 6 inches from the floor to accommodate tall individuals.

from this period on, they will be associated with the tortuosity and density resulting from arteriosclerosis. It is in the latter

untreated patients to an average of 65 months in patients receiving one year or more of such treatment."

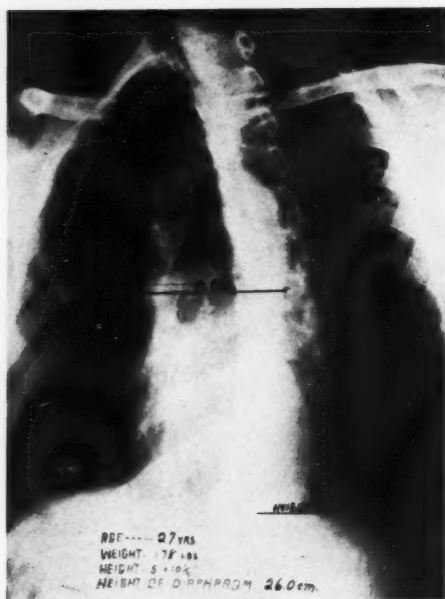


Fig. 7. Left anterior oblique roentgenogram. Sthenic type, age 27 years.



Fig. 8. Illustrating the changes that take place in an ordinary rubber tube both ends of which have been previously fixed in position, when it is subjected to air pressure. The shaded portion shows the tube before distention. The broken lines indicate the shape after air pressure has been applied. Note that, as the tube is distended, the limbs separate and the arch is elevated.

period that the posterior mediastinal borders of the aorta may be visualized, but not before.

Let us consider in more detail the most important of these three types, namely, the syphilitic. After all, so far as treatment is concerned, we are most interested in this type. The observations of Moore and Dangle (7) are pertinent. "A study of 43 patients with aortic aneurysm demonstrates that life may be prolonged from an average of nine months from the onset of symptoms, in untreated patients, to an average of 69 months in patients receiving one year or more of such treatment. A study of 90 patients with aortic regurgitation and eight with various other forms of syphilitic cardiovascular disease shows that life may be prolonged from an average of 32 months from the onset of symptoms in

A thorough appreciation of the pathology of the syphilitic process in the aorta is essential to an understanding of the roentgen changes. White's (8) excellent description is quoted briefly: "Three important developments of this destructive luetic aortic process may occur: (A) a stretching of the aortic wall to give rise either generally to a spindle-shaped dilatation or aneurysm, or locally to a saccular aneurysm; (B) an involvement of the aortic valve to deform it and to cause aortic regurgitation, and (C) a narrowing of the mouths of important branches of the aorta by an extension of the luetic process itself. . . . (B) Aortic valve disease . . . is due to a downward extension of the aortitis to involve primarily the commissures of the valve. The inflammatory

process widens the commissures by causing adhesions of cusps to the aortic wall and, by separating the cusps, produces regurgitation. This is the reverse of the usual rheumatic effect, which tends primarily to unite the cusps at the commissures, to cause stenosis rather than regurgitation. Extension of the luetic process may further damage the valve cusps themselves and cause their retraction or adhesion to the sinuses of Valsalva. A weakening of the aortic valve ring, with stretching, often comes with aortitis. Thus aortic regurgitation, so frequently complicating luetic aortitis, may result either from this stretching alone or from damage to the valve, or from both factors." The aortic regurgitation results in dilatation of the left ventricle (Fig. 11).

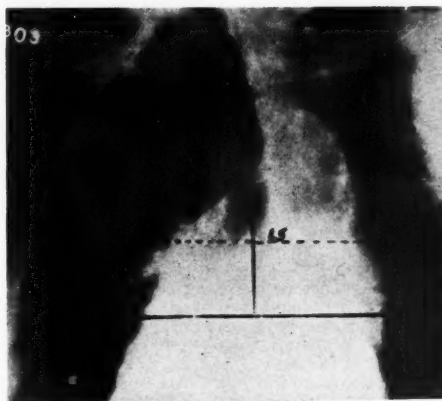


Fig. 9. Dilated aorta in hypertensive heart disease. Wide arch with descending border displaced beyond interspinous line.

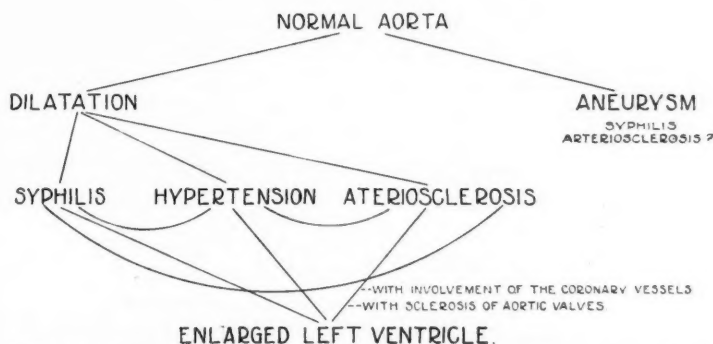


Fig. 10. Diagram illustrating the two most important pathologic changes in the aorta and the etiologic factors involved. The relation to enlargement of the left ventricle is also demonstrated.

The fact that the enlargement of the left ventricle takes place, usually secondary to the involvement of the valves, accounts for those cases in which the aorta exhibits an aneurysm and the heart shadow appears normal in size.

These facts have still further significance in that they may be utilized to differentiate between syphilitic and rheumatic, or non-specific, valvular disease. The latter type is very rarely associated with a dilated aorta. Therefore, a diagnosis of syphilitic valvular disease can usually be made with the aid of the roentgen examination

when the following conditions obtain: patient younger than 50, with an aortic diastolic murmur, dilatation of the aorta, and enlargement of the left ventricle, but no hypertension. On the other hand, if the above conditions prevail without dilatation of the aorta, then the converse is true, namely, rheumatic, or non-specific, valvular disease. These observations confirm those made by Holmes (9).

A statement concerning the roentgen changes in the early stages of syphilitic aortitis may not be amiss, although this should hardly be necessary. Occasionally,

one observes patients presenting the characteristic features of syphilitic aortitis, *i.e.*, precordial distress, dyspnea, and



Fig. 11. Diagrammatic sketch<sup>4</sup> illustrating the difference between aortic regurgitation resulting from rheumatic or non-specific valvular disease (B), and syphilitic valvular disease (C). Note that in the former the free margins are affected, while in the latter the valves are separated at the commissures by the syphilitic process which has extended downward from its supra-valvular origin. A represents the normal relation of the valves.

positive Wassermann, yet in whom no dilatation or aneurysm of the aorta can be detected. It should be readily appreciated that the early involvement of the adventitia and media by syphilitic process may not cause sufficient destruction of the elastic fibers to effect a dilatation or aneurysm. This is especially true before the fourth decade, when the aorta still retains abundant elastic tissue. Mention was made in the early part of this presentation concerning the difficulty of distending, experimentally, the aorta in a young adult. In such cases, however, it is advisable to make serial observations of the aorta during the course of treatment and thereafter, to determine the progress of the disease.

#### SUMMARY

1. The roentgen examination will disclose syphilis of the aorta in from 10 to 30 per cent of the cases in which it is not detected by other means.

2. It is obligatory, therefore, for roentgenologists to take an active interest in this subject and to make still further contributions.

3. The diagnosis of an aneurysm of the

aorta, and particularly dilatation, depends upon a clear conception of the normal aorta.

4. The aorta is best studied in the left anterior oblique position at an angle of 25°.

5. A graduated revolving platform is described for making roentgenograms in this position. The technic for its use is given in detail.

6. Until a technic is obtained whereby the outlines of the individual limbs of the aortic arch are plainly visualized, reliance must be placed on indirect measurements.

7. An appreciation of simple tube mechanics will aid in the study of the aorta.

8. The characteristics of the normal aortic arch are described.

9. Periodic health examinations, utilizing roentgen studies, may disclose an aneurysm or dilatation of the aorta in its early stages.

10. The presence of an aneurysm of the aorta, with the questionable exception of arteriosclerosis, will establish the diagnosis of syphilis.

11. Dilatation of the aorta is commonly found in syphilis, hypertension, and arteriosclerosis. These may exist singly or in combination.

12. The characteristics of the arteriosclerotic aorta must be appreciated to understand the roentgen changes in syphilis or hypertension when it is a coexistent factor.

13. A clear conception of the pathology of syphilis is essential to an understanding of the roentgen changes in the heart and aorta.

14. A differential diagnosis can be made between syphilitic and rheumatic, or non-specific, valvular disease with the aid of the roentgen observations.

15. At the risk of stating a platitude, the roentgen examination should always be correlated with the history, physical findings, and other clinical methods of investigation.

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<sup>4</sup> Personal communication from Dr. Robert Koritschoner, pathologist at Menorah Hospital.



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## OPAQUE MEDIA IN UROLOGY, WITH SPECIAL REFERENCE TO A NEW COMPOUND, SODIUM ORTHO-IODOHIPPURATE<sup>1</sup>

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THE term pyelography or pyelo-ureterography is universally accepted as defining the roentgenologic demonstration of the urinary conducting system—calices, pelvis, and ureter—with the aid of substances opaque to the x-rays. This method of investigation, historically, is intimately associated with the development of various opaque media in their application in urology. The substances to be considered for this purpose may be classified as:

1. Colloids
2. Crystalloids 

{	inorganic halogens— iodides or bromides organic halogens
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3. Gases—oxygen, carbon dioxide, and air

The first crude but stimulating attempts at delineating the pelvis and ureter were made by Tuffier in 1897, and Schmidt and Kolischer, Löwenhardt, and von Illyes, by means of mandarins passed through ureteral catheters, and opaque bougies. The first impetus to the delineation of the urinary tract with the aid of opaque media should rightfully be attributed to Wulff, of Hamburg. He outlined the urinary bladder by means of injection of a suspension of bismuth subnitrate. Voelker and von Lichtenberg working with collargol reported, in 1905, their experiences with the visualization of the urinary bladder. In the course of their work they were able to see the ureter and pelvis outlined in a case of unilateral vesico-ureteral reflux. In 1906, as a consequence, they published their results on retrograde pyelography with the aid of collargol injected through a ureteral catheter, and were thus the first

ones to completely and satisfactorily outline roentgenologically the pelvis and calices.

Other observers subsequently have utilized stronger solutions of collargol. Argyrol, as well as a 5 per cent emulsion of silver iodide, were the other silver compounds employed. Although in some hands these media have met with success, the use of the silver salts was finally abandoned, fatalities having been recorded, in part due to the character of the medium employed. For example, local necrosis in the kidney, silver embolism, and general poisoning, were some of the untoward reactions encountered.

A distinct improvement on the above media came with the advent of a 10 per cent solution of thorium nitrate, introduced by Burns, in 1915. This substance led to the gradual exclusion of the colloidal silver compounds. Associated irritative phenomena and fatalities were the objections raised to it. Yet, for three years until the advent of the inorganic halogens, this medium was the one of choice.

A notable advance occurred, in 1918, when Cameron suggested sodium and potassium iodide in watery solution, and Weld proposed sodium and potassium bromide. The potassium salts in both cases were quickly ruled out because of the depressant effect of the potassium-ion, particularly on the heart, as borne out by experiments on dogs with the intravenous injection of these salts. Based on these researches and clinical experiences, sodium iodide and bromide have come into almost exclusive use as pyelographic media. With regard to the comparative values of sodium iodide and sodium bromide, the former has been found to be superior for the following reasons:

<sup>1</sup> Presented before the American Congress of Radiology, at Chicago, Sept. 25-30, 1933.



Fig. 1. Intravenous urogram, in a case of vesico-vaginal fistula of tubercular origin, incidental to renal tuberculosis of a left excluded kidney. The urine was repeatedly negative for tubercle bacilli. A biopsy of the bladder in the region of the fistula showed tuberculosis. The right urinary tract reveals dilatation of the ureter, pelvis, and calices, with angulation and kinking of ureter.

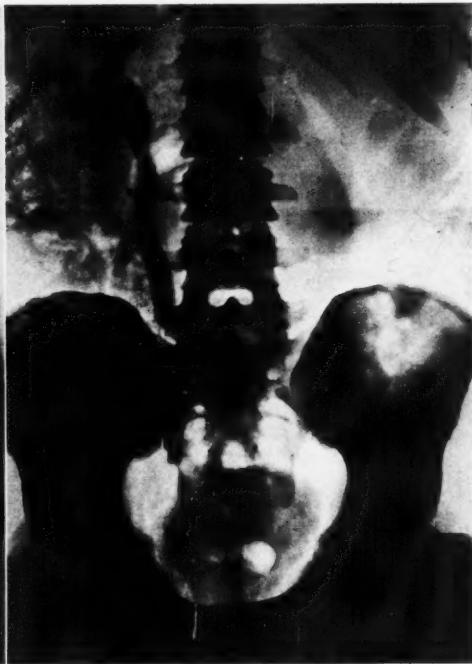


Fig. 2. Intravenous urogram, in a case of right non-functioning calculus hydronephrosis. The left urinary tract is dilated, the result of a stone situated over the lateral aspect of the midsacral region.

1. Its greater molecular weight, giving a radiographic shadow of greater density with a solution of much lower concentration.

2. The iodide component is a member of a group of elements which show an opacity to x-rays beyond what their atomic weight would indicate.

3. The osmotic pressure of sodium iodide in the concentration used for pyelographic purposes is only slightly greater than that of concentrated urine, and, of all the various substances used, is the least hypertonic. The question of hypertonicity becomes important when it is realized from animal experimentation as well as from clinical observation that, other things being equal, the injurious ac-

tion upon living tissues varies with the degree of hypertonicity. And herein lies the rationale for the general acceptance of a 12 per cent solution of sodium iodide for retrograde pyelography.

In passing, brief mention should be made of other media and procedures advocated, and in many instances subsequently discarded.

*A. Media.*—1. The use of oxygen, air, or carbon dioxide—the objection to these media being confusion with overlying intestinal gas, the difficulty of maintaining full distention of the pelvis and ureter, and air embolism. One of the authors (Jaches) has been misquoted as having advocated the use of air or oxygen. On the contrary, in the paper which he, in collaboration with



Fig. 3. Intravenous urogram, in a case of a left calculus hydronephrosis. There is non-visualization of the left urinary tract incidental to the functional-anatomic derangement of the kidney parenchyma. The right urinary tract shows dilatation of the calices, pelvis, and ureter. This case illustrates the value of non-visualization as a means of localization of the disease.



Fig. 4. Oral urogram, showing dilatation of the upper urinary tract of the remaining right kidney, after nephrectomy of the left one was performed for calculus pyonephrosis.

Dr. Furniss, presented, in 1911, which was not published but from which this quotation seems to have been derived, he distinctly stated that air or oxygen is distinctly inferior to metallic solutions for the reasons above stated.

2. Umbrenal or lithium iodide—this solution is expensive and frequently irritating, producing spasm of the calices and pelvis.

3. Lipiodol—of an oily consistency, has a tendency to globule-formation in the presence of aqueous solutions.

4. Umbrathor—a colloidal suspension of thorium dioxide, is similarly viscid, making emptying by the renal pelvis difficult. Its use in cystography, however, has definite advantages. The question of emptying in the case of the bladder is relatively of no consequence.

5. Neosilvol—in 20 per cent concentration has objections similar to lipiodol and umbrathor.

*B. Procedures.*—1. Perirenal and pericysto-pneumoradiography, a procedure by which oxygen is injected around the kidney and bladder, respectively. It has been practically discarded because of the meager information obtained and above all the attendant danger of air embolism and infection.

2. Pneumoperitoneum is the injection of oxygen into the peritoneal cavity for the differentiation of intra- and retroperitoneal masses. It is also unnecessary in most instances and at times coupled with danger.

3. Pyeloscopy, advocated in this country by Manges, and in Paris by Legueu, though satisfactory when practised by

them, is, in most hands, very unsatisfactory and unreliable, besides involving unnecessary exposure of the fluoroscopist.

4. The coating of non-opaque renal and ureteral stones with the injection of 2 per cent collargol and its subsequent aspiration has been shown to be unsatisfactory in the majority of cases.

5. Arteriography (introduced by De Santos), is the injection of sodium iodide into the aorta, thus outlining in addition to the abdominal vessels the renal arteries. It is considered by most urologists not only superfluous, but formidable and dangerous as a procedure.

6. Visualization of the seminal vesicles by means of injection of opaque media through the ejaculatory ducts has in most instances been difficult and not entirely helpful.

On the other hand, the following procedures which have withstood the test of time are worthy of detailed consideration.

1. *Cystography*.—This is a procedure which is used with the aid of both opaque solutions and air for the visualization of the diverticula, bladder stones, bladder tumors, prostatic conditions, and vesico-ureteral reflux. The following technic was employed and proved satisfactory: the bladder is filled through a catheter with a 3 to 5 per cent sodium iodide solution to the point of discomfort to the patient. Exposures in the anteroposterior and oblique or lateral positions are made. The bladder is then emptied and filled again with air and another anteroposterior roentgenogram is obtained. In cases of suspected vesico-ureteral reflux, an additional film is made in the trendelenburg position.

2. *Pyelography*.—A 12 per cent solution of sodium iodide or a 15 to 20 per cent solution of any of the organic iodides—iopax (uroselectan), neo-iopax, skiodan, neo-skiodan, or the newly developed compound, sodium ortho-iodohippurate (Swick)—is carefully injected through the ureteral catheter either by gravity or cystoscopically under vision until the patient complains of a fullness in the flank or the indigo carmine stained medium is visual-

ized at the meatus. Roentgenograms are made. Another is taken while withdrawing the catheter and simultaneously injecting the solution in order to obtain a uretero-pyelogram. The latter enables one to visualize both the condition of the ureter as well as negative shadows caused by non-opaque stones, tumors, blood clots, etc. Finally, in specified cases, an additional exposure is obtained after the catheter is withdrawn and the patient has been in a sitting position for ten minutes in order to determine trapping of the renal pelvis, as occurs in cases of aberrant vessels at the uretero-pelvic junction and in ptosis of the kidney. In performing a pyelogram, an attempt should be made at avoiding pyelovenous backflow—the forcing of opaque fluid into the veins overlying the fornices—and "*Büschelbildung*" (tuft-formation), the forcing of the pyelographic fluid into the collecting tubules. The pressure at which pyelography should theoretically be carried out, should accordingly not exceed the renal intravenous pressure. The importance of pyelovenous backflow and "*Büschelbildung*" arises from the difficulty introduced into the interpretation of the roentgenograms, particularly their differentiation from the pyelographic appearance in renal tuberculosis and renal neoplasms.

Retrograde pyelography is considered contra-indicated in the presence of acute urinary infections. In most institutions bilateral pyelography, at one sitting with the inorganic iodides, is not performed. The dangers associated with this procedure may be shock, infection, general sepsis, chemical poisoning, and local irritative phenomena.

#### THE DEVELOPMENT OF THE ORGANIC IODIDES AND THEIR PRESENT RÔLE IN UROGRAPHY

Beginning with the original contribution of one of the authors (Swick) with iopax (uroselectan) for excretion urography, stable organically bound iodides have come into practical use as urographic media. Subsequently, neo-iopax (uroselectan B),



skiodan, and neo-skiodan have been presented. One of the disadvantages to all of these is the cost of the dye. The organic iodides as a group appear to have been the least irritating to the patient without affecting the density of the shadow for bilateral retrograde pyelography.

To overcome certain obvious drawbacks, such as the large volume and dose, and the expense associated with the use of iopax (uroselectan), one of the authors (Swick) has developed a new organically-bound iodide compound which is here presented in greater detail. This substance, sodium ortho-iodohippurate, has, as a fundamental concept, the use of a normal product of metabolism as a nucleus for the iodine component necessary for roentgenologic visualization. In other words, it is the iodine derivative of a substance normally found in the human urine. For a more detailed consideration of the physiologic principles underlying the development of this substance the reader is referred to previous reports (1). The substance has met the necessary requisites for urography and has proven itself clinically adaptable for intravenous and oral excretion urography as well as for retrograde pyelography.

Sodium ortho-iodohippurate, a neutral salt, contains 38.8 per cent of iodine in stable organic union and is prepared as a white powder which is easily soluble in less than its own weight of water. The solution is prepared in sterile ampoules and remains unaltered, ready for use. The tolerance for the compound is good, and no unfavorable reactions, such as iodism, injury to tissues, or abnormalities in the urine, have been observed. Normally, from 90 to 95 per cent of the substance is excreted unchanged within eight hours after the intravenous injection.

#### PROCEDURE FOR INTRAVENOUS UROGRAPHY WITH SODIUM ORTHO-iodohippurate

Satisfactory urograms have been obtained in adults with doses varying from between 10 to 15 grams of substance in 50

per cent concentration (dose advocated, 12 grams in 25 c.c.). Children have received 10-gram doses (20 c.c.) without ill effects except for occasional transitory nausea and vomiting. The solution should be injected over a period of from three to five minutes. In the routine case the first film is taken ten minutes after the injection and two subsequent ones at from fifteen- to twenty-minute intervals. Later exposures should be made in cases of non-visualization or late visualization. The only complaint registered during and for a few minutes following the injection is generalized warmth. On the completion of the injection, compression is applied and left undisturbed throughout the period of the three exposures.

#### PROCEDURE FOR ORAL UROGRAPHY WITH SODIUM ORTHO-iodohippurate

To date, this substance is the only one on record to have yielded a high percentage of gratifying results: from 10 to 15 grams dissolved in approximately 75 c.c. of a mixture of simple syrup and elixir lacto-peptone have given suitably diagnostic radiograms. The only subjective sensation recorded is the salty aromatic taste of the solution. Nausea or vomiting has not occurred. Satisfactory results were obtained approximately from 60 to 135 minutes after administration. The patient is placed upon the x-ray table 45 minutes after the ingestion of the solution. A moderate degree of compression is applied over the urinary bladder region and x-ray exposures are made from 60, 90, 120, 150 minutes after the oral administration of the dye.

*The Use of Compression.*—We are convinced that, in order to consistently obtain clearly defined urograms, a moderate degree of compression over the region of the urinary bladder by means of an air-inflated rubber bag is quite essential. The balloon is held in place in the midline by means of the canvas-compression band, and left undisturbed during the x-ray examination from the time of the completion of the

injection. The opinion held by some that compression produces an artificial dilatation of the urinary tract has not been confirmed by our experiences.

conditions are preferably investigated by the excretory rather than by the retrograde route. The non-visualization of the urinary tract viewed together with the com-



Fig. 5. Intravenous urogram, in a case of uretero-pyelo-nephritis, showing dilatation of both urinary tracts, more marked on the right side, with angulation at the uretero-pelvic junction.



Fig. 6. Oral urogram, same case of uretero-pyelo-nephritis, for comparison with intravenous result, showing dilatation of both urinary tracts: more marked on the right side with angulation at the uretero-pelvic junction.

*Indications.*—In general, indications for excretory urography are evident in all cases in which retrograde pyelography is recommended, and particularly when the latter procedure in the presence of infection or mechanical difficulties is contra-indicated. Such mechanical difficulties may be hematuria, cases of reimplanted ureter, cases of anomaly, children, individuals in whom instrumentation is taxing and dangerous, and obstructive lesions such as stones, strictures, and neoplasms. Cases presenting obscure abdominal symptoms and

posite clinical picture can of itself be of great assistance in the localization of the disease and in establishing the diagnosis.

*Contra-Indications.*—Excretory urography is of no value for anatomic diagnosis in cases of uremia or latent uremia. Under such conditions the injection of any substance may be an accompanying or contributing factor to exitus. On the other hand, to determine the renal function simpler and cheaper methods may be resorted to.

# RETROGRADE PYELOGRAPHY WITH SODIUM ORTHO-IODOHIPPURATE

Solutions in from 15 to 20 per cent concentration have given satisfactory bilateral retrograde pyelograms at one sitting without untoward effect to the patient.

Without entering into a detailed account pertaining to the various aspects of renal function in its relationship to excretory roentgenologic visualization, it should be strongly pointed out that excretory urography, in contra-distinction to retrograde pyelography, which is purely a mechanical, non-physiologic filling of the pelvis and calices, is excretory in nature and, therefore, dependent upon renal and extra-renal variations. In order to avoid repetition, the reader is referred to earlier publications for such important considerations concerning excretion urography as, for example, renal function and excretion urography, renal function and radiologic findings in hydronephrosis, temporary functional inhibition, and non-visualization as an aid in localization of the disease and in establishing the diagnosis.

## CONCLUSIONS

Urography represents a notable advance in the science of medicine. Its claim to

recognition as a science strongly rests upon the precision, accuracy, and rational thinking that it adds to diagnosis. The fact that excretion urography, since its development upon broad practical principles, has been a definite and invaluable contribution is not challenged. Excretory and retrograde pyelography should complement and supplement one another. One's attitude should be that of employing both methods intelligently and to the best advantage, rather than focusing one's attention on which of the two procedures is the better. In our experience we have found excretion urography to be in general useful, and in particular, where retrograde pyelography is contra-indicated because of the presence of infection or mechanical difficulties. Similarly, retrograde pyelography is essential in corroborating or supplementing the equivocal results of excretion urography.

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## BULLOUS EMPHYSEMA(?) OR BILATERAL PNEUMOTHORAX(?)<sup>1</sup>

By EPHRAIM KOROL, M.D., *Lincoln, Nebraska*, and C. F. ENSIGN, M.D., *Hines, Illinois*

### ACKNOWLEDGMENT

WE are prompted to write this article because of a paper entitled "Chronic Bilateral Spontaneous Pneumothorax" recently published by Joseph Lewis (1). Lewis describes a case in which the clinical and x-ray findings justified a diagnosis of chronic bilateral spontaneous pneumothorax. He made an exhaustive search of the literature and was unable to find a like case. We have had the privilege of observing two such cases; in the first one we made a diagnosis of bilateral pneumothorax, but after further experience with the second case, after familiarizing ourselves with the physiologic factors concerned, and after a review of the literature, we came to change the diagnosis to that of bullous emphysema. The experiences of Haahti (2) proved especially illuminating to us in this respect.

*Physiological Considerations.*—The laws governing the diffusion of gases in a closed body cavity are such that a closed pneumothorax cannot persist without marked contraction of the affected side of the chest. When the spontaneous pneumothorax first occurs, the partial pressure of the gases in the cavity is the same as that in the atmosphere and much greater than that of the gases in the blood and tissues. There immediately begins a diffusion of the gases from the pneumothorax into the blood, with a progressive drop of pressure in the pneumothorax cavity. Only after the pressure drops to about 95 cm. of water below atmospheric pressure will there be an equilibrium established so that further absorption will not occur (3). As a result of the low pressure in the pneumothorax, the overlying chest wall is compressed

and the abdominal viscera are crowded upward by the atmospheric pressure. In the cases reported by Lewis and Haahti as well as in our own two cases, there were no signs of contraction of the chest, and the pressure in the air chambers was not much below atmospheric. These findings alone are sufficient to rule out pneumothorax. Even open pneumothorax leads to contraction of the chest unless the outside opening be larger than the glottis, which is hardly compatible with life. Moreover, an open pneumothorax invariably becomes infected and fluid develops in it. In the cases under discussion, there were no symptoms of sepsis and no fluid in the air chambers.

*Lewis' Case.*—A man aged 49 years had been developing increasing dyspnea for 7 years, and had been treated for asthma. There was hyperresonance over the upper lobes and no vesicular breath sounds. The x-ray appearance resembled closely that of our Case 1. There were no lung markings above the level of the third anterior rib on each side, suggesting bilateral pneumothorax. However, collapsed lungs do not show at the lung roots, and there can be seen no line of separation of the lung from the chest wall. A film made five days after the first examination showed the air chambers to be much larger, reaching down to the fourth rib on each side, yet there was no separation of the lower lobe from the chest wall. A manometer needle was introduced into the air pockets and the readings were plus 6, minus 2 on the left side, and plus 4, minus 2 on the right side. These readings plainly showed that the needle was in the lung tissue communicating with a bronchus and not in the pleural cavity. The patient died a few hours after the paracentesis, apparently due to a "superimposed acute pneumothorax" caused by the needle

<sup>1</sup> Published with the permission of the Medical Director of the Veterans' Administration, who is not responsible for the opinions expressed by the authors.



puncturing the lung. Lewis remarks: "Examination of the radiograms shows that the combined collapse would not be equivalent to a complete unilateral pneumothorax; yet why the marked dyspnea?"

*Haahli's Case.*—The patient was a youth aged 19 years, who had no complaints referable to the lungs. He had hyperresonance and absent breath sounds over the right upper lobe, and the x-ray film showed no lung markings over the upper half of the right lung, nor was there seen a collapsed lung. The exploring needle first entered the pleural cavity, the pressure having been found normal (minus 12). The needle was then deliberately inserted into the lung in which the abnormal air cavity was found. Pressure was minus 5 in inspiration, and minus 3 in expiration. After the aspiration of 750 c.c. of air, the pressure remained unchanged, which was interpreted to show that the communicating bronchus had a valve opening. The punctures resulted in a pneumothorax also in this case. Following the establishment of the pneumothorax, an x-ray film showed beyond any doubt that the original air cavities were in the lung proper.

*Case 1.*—The patient was 35 years of age at time of the examination. He had had fair health in childhood but could not indulge in any sports because of short-windedness. He served in the Army from March, 1918, until November, 1923, his duties in the service not being of a very strenuous nature. After his discharge from the service he found the civilian occupations too laborious. There was increasing fatigability and shortness of breath on exertion. He had been unable to work gainfully in the past four years. He began to seek medical attention in 1929. At that time he had pains in the chest on exertion related to deep breathing. After exertion he would become breathless and pain would appear on each side of the breastbone, worse on the left side. He learned to remain quiet and to breathe as lightly as possible for fifteen or twenty minutes; the pains would then subside. More recently, the pains and shortness of breath

had occurred without much exertion. There was no fear of death during the pains and no radiation of the pain down the arms. There was much cough and orthopnea at rest, and a gradual loss of some 40 pounds in weight.

The man was poorly nourished, weighing 117 pounds. He was dyspneic when active and occasionally cyanotic. His temperature was normal: respirations varied between 20 and 50 per minute. His heart was normal: his chest was short, broad, and flat, the clavicles being rather prominent. The upper chest did not expand; the lower chest expanded well. There was no tactile fremitus over the upper lobes. The percussion note anteriorly over the upper thorax was high-pitched, tending to be tympanitic. The breath sounds were absent over the upper half of the chest both anteriorly and posteriorly. The vital capacity was 2.6 liters, while the estimated capacity was 3.8 liters. The manometer needle entered the pleural cavity on each side. The pressure found was minus 2 to minus 8 cm. of water on the right side, and minus 6 to minus 10 on the left side. The lung was apparently not punctured and there were no untoward results. We believe that the abnormal air spaces were not entered by the needle.

The chest specialist remarked: "These pressures are not highly negative. In pneumothorax of long duration the pressure becomes much more highly negative. In this case there has been no marked absorption of air, and if this had occurred the remaining portions of the lung would have been drawn up into the upper thorax so that the lines visible in the lung would have their convexity upward rather than downward as at present. One of the striking facts is the absence of chest deformity. All that we know in this case is that the pneumothorax has been present since 1930. It is difficult to say why the air has not been absorbed in the intervening two years. This can be explained upon one of three bases: The first is that the pleural surfaces are thickened and absorption abnormally slow; this is not



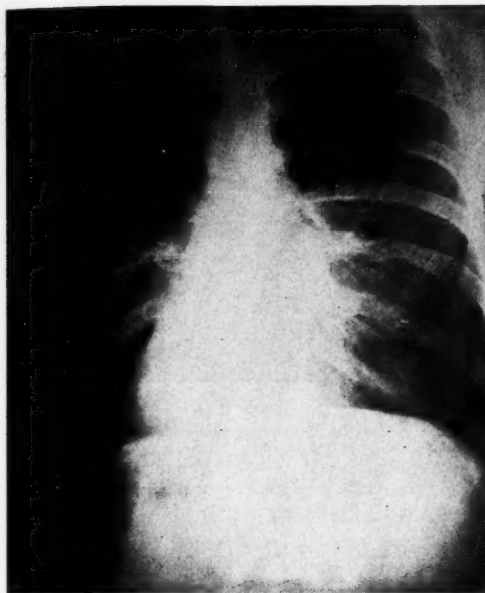


Fig. 1. Case 1. Bilateral pneumothorax or apical emphysema(?), see text.



Fig. 2-A. Case 2. Progression of bullous emphysema. On Sept. 16, 1930, there are no normal lung markings in either apex. There is a large emphysema bleb in the left apex, its lower border showing just below the clavicle. The three blebs in the right apex are separated by thickened septa.

probable. The second is that there is a persistent fistula: if this were the case, fluid would certainly be present and probably secondary infection. The third explanation is that as the lungs re-expand, the breaks in them are reopened and they again drop down. I have seen cases in which a lung has repeatedly partially expanded and then recollapsed. It is unlikely that this rather rare occurrence would happen in both sides in this case."

The roentgenologist submitted the following report: "We have a massive pneumothorax in both apices, extending down to the sixth interspace posteriorly on the right, and to the eighth on the left, extending anteriorly to the third on the right, and the fourth on the left. Below these zones we see lung tissue, apparently normal on the right but with abundant pleural adhesion on the left. I cannot see where the upper lobes have retracted to. One would expect at least a small rounded

shadow at the lung root representing the contracted upper lobe on both sides. I see no evidences of disease in the lungs to account for this type of pneumothorax. I do not see enough evidence of pleural adhesions to explain why the pneumothorax is limited to the upper part of the chest. I suppose the pleura must be adherent."

It will be observed that both the clinician and the roentgenologist were not quite satisfied with the diagnosis of bilateral pneumothorax, and for good reason: there was no pneumothorax.

*Case 2.*—The man was operated on for gangrenous appendicitis, in 1922, at the age of 25. He was said to have ether pneumonia. The convalescence was slow and he had a chronic cough. He has been examined periodically during the past twelve years. Tuberculosis was suspected but the diagnostic signs of pulmonary tuberculosis (*i.e.*, tubercle bacilli, moist râles, or typical x-ray shadows) were not

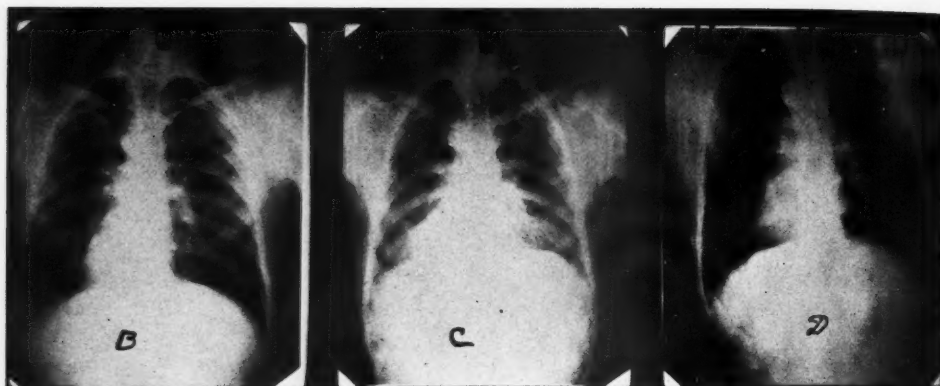


Fig. 2-B. On Oct. 29, 1933, the bleb in the left apex has enlarged and its visible border is lower in the chest. In the right apex, the blebs are also larger although but one septum persists (confluence of emphysema vesicles by rupture of septum).

Fig. 2-C. Film taken in expiration at the same sitting as B. The lung bases are deflated, but there is increased inflation of the emphysema vesicles (paradoxical breathing).

Fig. 2-D. Film taken in knee-chest position, at same sitting as B and C. Lung markings are now visible in the apices. Note the great transparency of the lung bases in this position.

demonstrated. In February, 1923, an x-ray examination of the chest was reported to show "some increased density in the extreme right apex slightly mottled in character; infiltration in right apex very suspicious of an early tuberculous lesion."

On Jan. 9, 1924, the roentgenologist reported: "The pulmonary markings extending up into the apices are granular and in the right apex there is a patch of webby shadow."

It must be assumed that, in 1924, there were lung markings in the apices. On Aug. 6, 1924, "both apices showed coarse mottling." On Feb. 29, 1928, the case entry reads: "Appears to have some small mottling in both upper lobes and near the apices." In September, 1930, the physical examination showed feeble breath sounds over the apices. The x-ray film (Fig. 2-A) showed a dense line running across the left upper lobe with no lung markings above this line; this was interpreted as a large emphysema bleb, the dense line being its thickened base. The right apex likewise showed no normal markings but there were two dense vertical lines representing thickened walls of emphysema blebs.

In November, 1933, the physical signs

were unchanged. The x-ray film showed an increase in the air chambers in the two apices. On the left side the dense line has moved down perceptibly. In the right apex only one of the vertical lines persisted, the other line disappeared, presumably due to rupture and confluence of the emphysema vesicles. An x-ray film made in expiration showed enlargement of the apices, with increased air content. A film made in the knee-chest position showed the appearance of lung markings in both apices.

#### DISCUSSION

Bullous emphysema is associated with strictures along the course of the bronchi (4, 5); during inspiration the bronchial lumen enlarges to admit air, during expiration the lumen about the stricture is obliterated, so that there results an obstructive emphysema. The expiratory enlargement of the emphysema blebs may be observed fluoroscopically (Fig. 2). During postmortem examination, compression of the lung causes inflation of the blebs. During labored breathing, as after exercise or excitement, there occurs an air exchange between the normal and emphysematous

areas (6) as well as between the normal lung and the atmosphere; the stale air from the emphysema blebs may reach the normal alveoli in advance of the atmospheric air, thus adding to the respiratory distress. The attacks of dyspnea and cyanosis observed in Lewis' case and in our Case 1 thus find explanation, also the fluctuating size of the air chambers in Lewis' case. But for this paradoxical breathing one would not expect much dyspnea in these cases, as the apical regions of the lung normally participate but slightly in respiration. Extensive tuberculous infiltration may exist in these regions without causing dyspnea.

*Differential Diagnosis.*—The physical signs are very similar in emphysema and in pneumothorax: the x-ray appearance may also be inconclusive. In apical pneumothorax there is no lung to cast the typical x-ray shadows; in emphysema the blood vessels which are responsible for these lung markings are very small in films made in the usual manner, *i.e.*, with the patient standing or sitting. In the erect position, the blood vessels in the lung bases are engorged, the apices being relatively ischemic so that they appear very transparent as compared with the lung bases. In apical emphysema, due to the poverty of blood vessels typical of this condition, no markings may show on films made in the erect positions. In these cases a film made in the knee-chest position helps to establish the diagnosis: in apical emphysema lung markings appear in the knee-chest films, in pneumothorax

or tuberculous cavity, complete radiolucency persists (Fig. 2).

#### SUMMARY AND CONCLUSIONS

1. Bullous emphysema can closely simulate partial pneumothorax.
2. In a given case, if the condition is of long duration the diagnosis is in favor of emphysema rather than pneumothorax.
3. Retraction of the chest wall and of the viscera points to pneumothorax; absence of retraction points to emphysema.
4. Bullous emphysema is generally associated with bronchial strictures which have a ball-valve action: the emphysema blebs are larger on films made in expiration.
5. If the x-ray film is taken with the patient in the knee-chest position, lung markings appear in the emphysema blebs; in apical pneumothorax the lung markings remain absent in all positions.
6. Investigation of the intrathoracic pressures with a needle is fraught with danger in these cases, and is not likely to furnish diagnostic information.

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## NEW DEVICE

### THE CORPIOMETER<sup>1</sup>

A CONTOUR GAUGE FOR OBTAINING CROSS-SECTION BODY OUTLINES

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In order to accurately estimate the proper roentgen dosage that is to be delivered to a deeply seated lesion by high voltage x-ray irradiation, it is necessary to know definitely the size and shape of a cross-section of the body at the level in which the lesion to be treated is located. Several methods of obtaining such information are in common use, such as measuring the diameters in sagittal and transverse planes, the use of lead wires to obtain an outline, etc. Thinking that perhaps some method

part in reality consists of a single contour gauge made up of 46 wooden strips placed one upon the other to a height of 11 inches. These strips are slotted through the center. An iron rod traverses all of the slots and passes through a hole the same size as the rod, that has been bored through a heavier piece of wood which is longer than the strips and acts as the top and a handle. The end that passes through the handle is threaded and fitted with a thumb nut. Thus by a few turns of the thumb nut the strips of wood can be securely fastened in position or loosened so that they move freely backward and forward. Each piece of wood measures  $11\frac{1}{2} \times \frac{3}{4} \times \frac{3}{8}$  inches. One side contains a groove  $\frac{1}{8}$  inch in depth, the other side a tongue  $\frac{1}{16}$  inch thick, the tongue of one fitting into the groove of the other. This allows free movement in one direction and prevents side movement when the thumb nut is loosened.

In order to obtain the outline of both sides of the body at one time, these two sets of wooden strips are joined together by a hinge. This allows the convex side of the body to be measured and the gauge removed without disturbing the strips of wood.

Figure 1-A illustrates the gauge as it appears after having been adjusted to a patient and removed. The handles are at the top of the illustration. The thumb nuts can be plainly seen on the upper border at the middle of each handle. The strips of wood, one above another, give a laminated appearance to the gauge. The space in the center of the corpiometer represents the outline of the patient's body.

In Figure 1-B, the thumb nut has been removed from the iron rod and the latter withdrawn from about half of the strips of wood. Some of the strips have been turned so that the grooves, tongues, and slots can be seen. In order to facilitate the sliding movement of the strips upon one another they have been sanded and fitted to each other carefully and a thin coating of paraffin applied.

In Figure 2, the different steps in its use are illustrated. A shows how the gauge is placed around the part of the patient to be measured. The strips have been adjusted to conform to the outline of the body and the thumb nuts, which were previously loosened so as to permit free movement of the strips, have been tightened, thus fixing the strips in the position which conforms to the outline of the body.

In Figure 2-B, the gauge is being removed. The one side is being lifted upward while the other side remains in position. This is accomplished by bending one side upward and backward toward the other through the intermedi-

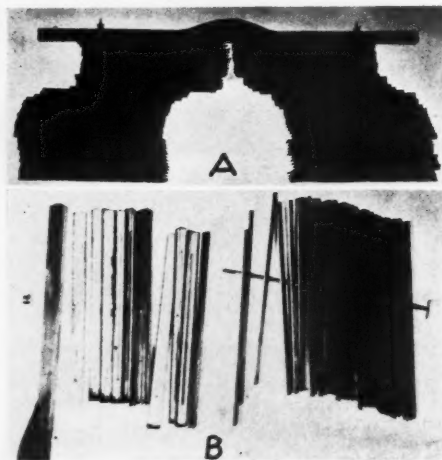


Fig. 1-A. Gauge, after having been adjusted and removed.

Fig. 1-B. Thumb nut removed from iron rod and later withdrawn from about half of the strips. Some strips are turned, to show grooves, tongues, and slots.

could be devised whereby the outline of the body at any desired level could be quickly and accurately determined, a mechanical engineer was consulted. He suggested using a modification of the contour gauge.

Accordingly such a gauge was designed and made. It consists of two similar parts hinged together so that they can be quickly adjusted and removed from the patient's body. Each

<sup>1</sup> Received for publication April 26, 1934.

ary of the hinged joint which fastens the two handles together.

In Figure 2-C a tracing is being made on thin semi-transparent paper of the space which represents a cross-section of the body, the gauge

The device has been in constant use for about six months. With it, much time is saved and it has been found so far superior to any other method hitherto employed by us that it was thought perhaps others might find its use

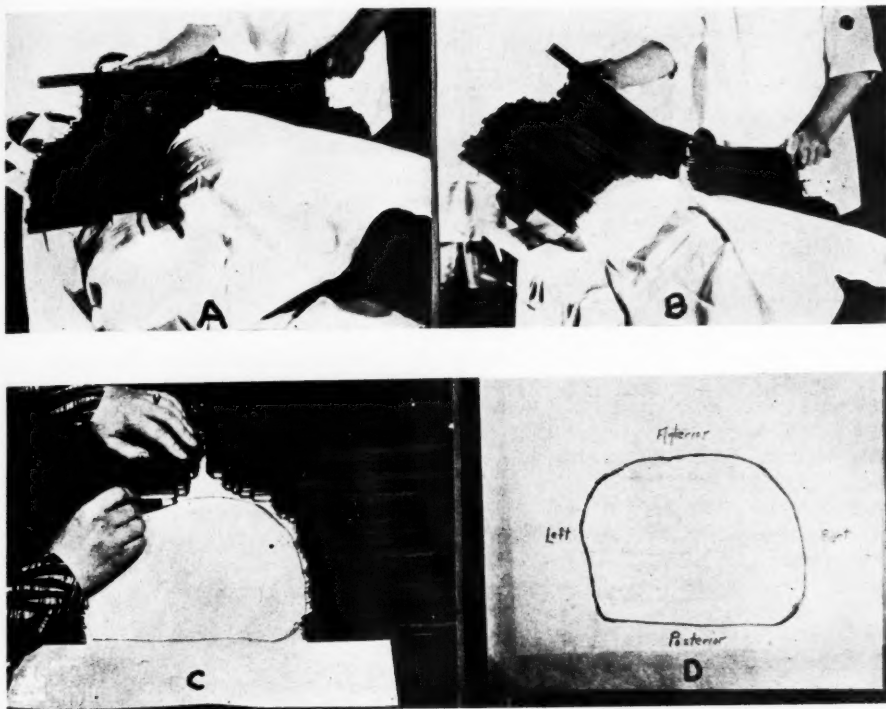


Fig. 2-A. Gauge on body of patient.

Fig. 2-C. Tracing being made on thin paper.

Fig. 2-B. Gauge being removed.

Fig. 2-D. Tracing placed upon isodose chart.

having been placed on the paper with the laminated strips in the exact position they held when adjusted to the patient. The outline thus obtained accurately portrays both the size and the shape of the body at any particular level. The paper with the outline traced upon it is then placed on isodose charts, as in *D*, and estimates as to dosage made.

just as advantageous. There are no complicated parts to get out of order; one can learn to use it without instruction; no accessories such as charts, cuts, or lantern slides are needed, and an accurate outline of a cross-section of the body at any desired level can be obtained with the patient in any position.



# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## SELECTION, EDUCATION, AND SUPERVISION OF X-RAY TECHNICAL WORKERS

When the x-ray first came into use, each person working with the particular equipment at his disposal, developed his own personal plans and technic. This was necessary because of the great variation in the poor equipment then in use.

With the developments of radiology a new and entirely unique problem confronts the medical profession. This problem develops because of the highly specialized technical and scientific procedures that are necessary to do useful x-ray work in both diagnostic and therapeutic lines. With the vast amount of x-ray work being done and the demand for economic services to the patients, it is impossible for the radiologists to personally do this technical work. Likewise, surgeons or physicians practising other specialties of medicine cannot properly do x-ray technical work because of their lack of knowledge and of training in x-ray activities, and likewise because they do not have the time to properly do x-ray work in conjunction with successfully carrying on their other professional work. Then, too, in spite of the high-pressure salesmanship of the x-ray concerns, physicians in general practice are coming more and more to realize that it is a financial waste for them to put in x-ray equipment, pay the rent on the necessary extra space that this equipment would occupy, and carry on the over-head expense of maintaining such equipment in conjunction with their regular lines of professional work.

For these and other reasons, it is now quite generally understood and agreed upon that there must be a distinct class of technical workers, commonly designated as x-ray technicians, to do this necessary technical work included in the x-ray activities of the present. Experience has proven that it requires a higher degree of intelligence, a higher degree of mechanical skill, and especially a more stable temperament to successfully meet the duties devolving upon the x-ray technician than are required of a registered nurse.

The medical profession, therefore, is confronted with the problem of the selection, education, and supervision of this new and extensive group of technical workers who have become a necessary adjunct to the practice of medicine.

It goes without saying that the surgeons should select and control the training of surgical nurses. In like manner no one but the experienced roentgenologist is capable of controlling and directing the selection, training, and activities of the x-ray technical workers.

All new medical discoveries and activities have been seized upon by impostors and quacks of all kinds to be exploited for their commercial benefit. The x-ray has been no exception to that rule. The rather large number of "commercial" x-ray laboratories still in existence is a dangerous menace to the welfare of the patients sent to such laboratories by physicians who are not fully informed of the dangers of such procedures, or by certain other physicians whose standards of ethics permit them to make dishonest financial arrangements with these "commercial" laboratories, always to the detriment of their patients. This is a standing disgrace and menace to the public.

It follows that these technical workers should be carefully selected and trained in proper institutions where a definite standard course of training can be maintained. They should be supervised by roentgenologists of recognized standing. These trained workers should be so registered and organized that they will be under the control of the medical profession. They should be particularly under the control of the specialists in the medical profession who are competent to look after the x-ray activities of the practice of medicine. To this end, an examining and registration board, composed of properly selected roentgenologists and possibly some other members of the medical profession, which should function for the entire North American continent, affords the most practical basis of control. The x-ray technical workers should be ex-

amined and found worthy and qualified to be registered as such technical workers, and then organized into a national society or association as one of the necessary requisites for improving themselves. This national organization would both promote the proper spirit of organization and development of said technical workers, and also keep them under the direct control of the examining board above mentioned. Of course, to make this fully binding, there should be a requirement of annual renewal of their certificate for the practice of technical work issued by said Radiological Technicians Examining Board. The fees for these examinations and reissuance of certificates need not be at all excessive. A merely nominal fee of five dollars for the original examination, and a fee of about two dollars for each renewal certificate annually would probably cover all the costs of conducting this work and would not in any way be a hardship upon the x-ray technical workers.

It is quite certain that if any state or any small municipal government be allowed to assume any regulation as to the selection, education, examination, and registration of these x-ray technical workers, petty politics and political graft and incompetency will at once creep into all such state or other local attempts to register and regulate their activities. This would be a dangerous menace to the medical profession and to their patients.

As organized at present the Radiological Society of North America provides a Registry Board for the examination and registration of the workers in the field of radiographic technic. This Registry Board imposes certain conditions upon the applicants for registration. Among these conditions are the following: The technician must work under the supervision of a qualified radiologist; the technician must limit his work in radiography absolutely to the technical application of x-rays. Certain restrictions are also placed upon the ethics of the technical workers. The x-ray technicians have a national organization known as the American Society of X-ray Technicians, numbering between 450 and 500 members, which is functioning and co-operating with the radiologists and roentgenologists throughout the country. Affiliated with the national organization are local organizations of technical workers located in the larger centers of population and fairly well distributed through-

out the country. The national organization has a Council appointed by the President of the organization and composed of members of the national technical organization and also having as members three or more radiologists, members of both the Radiological Society of North America and the American Roentgen Ray Society. The duties and functions of this Council are to promote educational projects that will help to increase the efficiency of the technical workers in x-ray and also to co-operate with the Registry Board of the Radiological Society of North America to the fullest extent in all things tending to help the interests of radiography and to increase the efficiency of the x-ray technician.

The American Society of X-ray Technicians solicits the co-operation of the radiologists and roentgenologists of the country in helping to place the work of the x-ray technicians of the country at the highest level of scientific attainment in the field of x-ray technic.

The American Registry of Radiological Technicians of the Radiological Society of North America with the co-operation of the Council of Education and Registration of the American Society of X-ray Technicians has approved a standard course of training and instruction, the length of time of which is one year. This length of time in training will very probably be increased to two years in the very near future. This standard course of training is given by institutions approved by the American Registry of Radiological Technicians of the Radiological Society of North America.

It is hoped that in the near future one of the requirements for a Class A Hospital may be that the x-ray technician in charge of the technical work in the x-ray department of said hospital shall be a Registered X-ray Technician. This said registration would certify that the technician had a standard course of training and instruction, had passed the tests of the American Registry of Radiological Technicians of the Radiological Society of North America both in theory and practice, had a sufficient time of experience in technical work, and was fully qualified in that branch of medical science.

This qualification of x-ray technicians covers the entire territory of both United States and Canada.

It will thus be seen that the training and regulation of the x-ray technicians is fairly

well organized and supervised at this time. It is hoped that all medical organizations will be in sympathy with this movement and co-operate with the various roentgenological and radiological organizations to place the personnel and efficiency of the x-ray technicians on the highest plane possible.

## COMMUNICATIONS

### PROGRAM OF THE ANNUAL MEETING

The following tentative schedules are offered to our readers thus far in advance of the date of the Annual Meeting, by their originator, Dr. W. H. McGuffin, with the thought of giving an outline of the character of the Scientific

Sessions. No doubt program arrangements will change as the plans mature and the number of papers to be presented increases, but at present they serve to give one an idea of the classifications under which the presentations will likely be grouped. At any rate, it does not leave matters to chance and the prospective essayists to speculation; such changes as seem needful will be made later in the year. Constructive suggestions are invited.

The program is rapidly taking form. The division of Diagnosis is under the leadership of W. W. Wasson, M.D., of Denver. A symposium on Silicosis is being arranged by E. C. Ernst, M.D., of St. Louis; a symposium on Arthritis by H. P. Doub, M.D., of Detroit; a symposium on Urography by B. H. Nichols, M.D., of Cleveland; a symposium on Thoracic Neoplasms by J. T. Farrell, Jr., M.D., of

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:30 to 10:30	Registration and Opening Ceremonies	Silicosis	Arthritis	Buccal Cavity and Neck	Dermatology
10:30 to 12:30	Urology	Thoracic Neoplasms	Physics of Radiation	Breast and Pelvic Viscera	Bone Pathology
12:30 to 2:00	Lunch				
	TECHNICAL AND SCIENTIFIC EXHIBITS				
2:00-2:30 2:30-3:00 3:00-3:30	Gastro-intestinal Tract	Executive Session  "Unification of Societies"	Super-high Voltage	Executive Session  "Economics"	Spinal Lesions
	SCIENTIFIC EXHIBITS				
3:30-4:30	Scientific exhibitors: 15 minutes each	Scientific exhibitors: 15 minutes each	Scientific exhibitors: 15 minutes each	Scientific exhibitors: 15 minutes each	Scientific exhibitors: 15 minutes each
	Clinics	Clinics	Clinics	Clinics	Clinics
4:30-5:00 5:00-5:30 5:30-6:00	See following schedule	See following schedule	Recreation	See following schedule	See following schedule

CLINICS						
Monday and Tuesday						
Time	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6
4:30	Esophagus	Encephalography	Accessory Nasal Sinus Technic and Interpretation	Roentgen Therapy: Thyroid Disease	Intravenous Urography	Physical Method of Calculating Roentgen Dosage
5:00	Stomach and Duodenum	Ventriculography	Opaque Oil Visualization, Accessory Nasal Sinuses	Roentgen Therapy: Breast Pathology	Retrograde Urography	Measurement of Radiation Dosage with Instruments
5:30	Colon	Spinal Canal Tumors	Mastoid Sinus Technic and Interpretation	Roentgen Therapy: Uterine Pathology	Hysterosalpingography	Physical Method of Calculating Roentgen Dosage

CLINICS						
Thursday and Friday						
Time	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6
4:30	Heart and Great Vessels	Radium Therapy: Oral Malignancy	Examination of Teeth and Interpretation of Films	Roentgen Therapy: Spinal Nerves	Radium Treatment: Uterine Malignancy	Physical Method of Calculating Roentgen Dosage
5:00	Opaque Oil Visualization of Bronchi	Radium Therapy: Breast Malignancy	Salivary Calculi and Sialography	Roentgen Therapy: Lymphoblastoma	Radium Treatment of Lesions of Female External Genitalia	Measurement of Radiation Dosage with Instruments
5:30		Radium Therapy for Thyroid Disease	Roentgenography of Larynx with Interpretation of Films	Roentgen Therapy of Skin Diseases		Physical Method of Calculating Radium Dosage

Philadelphia; a symposium on Bone Pathology by R. T. Wilson, M.D., of Temple, Texas, and a symposium on the Gastro-intestinal Tract by B. R. Kirklin, M.D., of Rochester, Minnesota.

## MEMPHIS, THE PLACE OF THE NEXT ANNUAL MEETING

The city of Memphis, Tennessee, where the next Annual Meeting of the Radiological Society of North America is to be held during the week of December 3 to 7, inclusive, is distinguished for the number of fine hospitals, among other features, located there. In presenting a preview of the Annual Meeting to the readers of *RADIOLOGY*, the Committee of Local Arrangements feels it cannot do better than show photographs of as many of these fine hospitals as possible. From them, physicians can best judge the size of the City of Memphis and its relation to the area of country it serves. In fact, Memphis may be called the City of Hospitals, institutions of which its medical profession may well be proud.

In this issue, we present views of the Baptist

Memorial Hospital, the Methodist Hospital, and the John Gaston Hospital, otherwise known as the New City Hospital. In later issues of *RADIOLOGY*, as space may permit, we will endeavor to present views of the other Memphis hospitals. It is in these institutions that the clinics which are so important a feature of the program of the Annual Meeting are to be held.

Members of the Society and its guests will be welcome at these institutions during the week of the Annual Meeting and gladly shown their facilities and equipment. The Committee feels that in no other way can radiologists visiting Memphis be so well shown the stage of progress made by radiology in this area of the middle South.

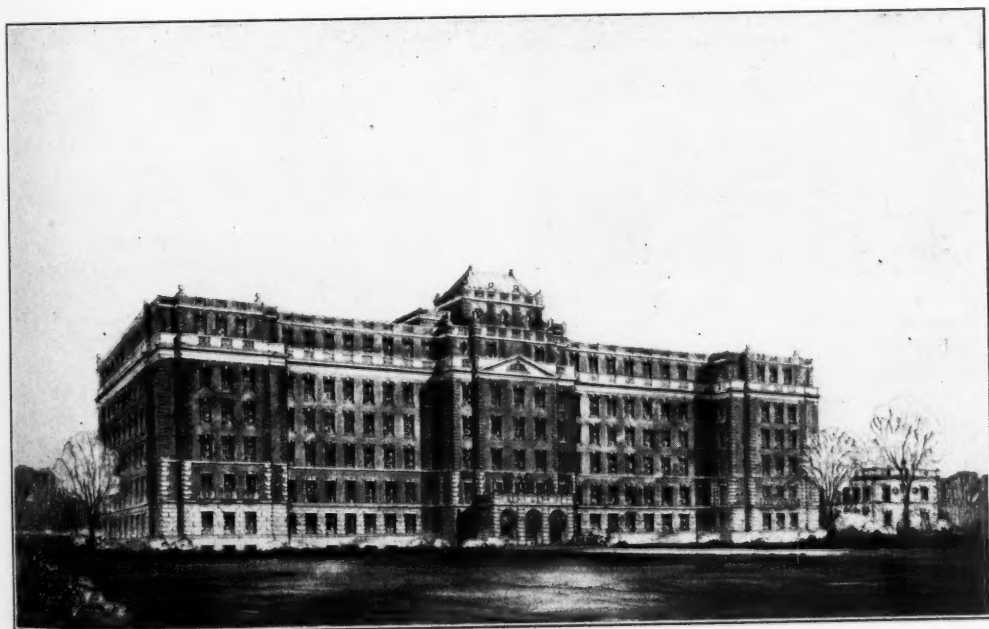


Baptist Memorial Hospital, Memphis.





Methodist Hospital, Memphis.



The John Gaston Hospital (New City Hospital), Memphis.

# THE ROENTGEN-RAY EXHIBIT AT A CENTURY OF PROGRESS

The opening of A Century of Progress in 1934 found installed in the Hall of Science a rather comprehensive exhibit of x-ray films illustrating the findings in twenty-five diseases selected because of their importance to public health and because of the valuable aid furnished by x-rays in their diagnosis.

Such an exhibit was noticeably absent in the Summer of 1933. The whole spirit of showing the lay public the basic factors in disease and the present day of diagnosis is new in the history of medicine. It was the very obvious absence of an exhibit in our newest specialty that prompted the Chicago Roentgen Society to sponsor an exhibit for 1934. Some six hundred films are shown.

The names of the forty radiologists who generously responded to the request for scientific material on the twenty-five diseases selected follow, and the committee preparing the exhibit greatly appreciates their co-operation.

Lewis G. Allen, M.D., Kansas City, Missouri.

Robert G. Allison, M.D., Minneapolis, Minnesota.

Lewis Gregory Cole, M.D., New York City.

Howard P. Doub, M.D., Henry Ford Hospital, Detroit, Michigan.

William A. Evans, M.D., Harper Hospital, Detroit, Michigan.

William G. Herrman, M.D., Monmouth Memorial Hospital, Long Branch, New Jersey, and Fitkin Memorial Hospital, Asbury Park, New Jersey.

Max Kahn, M.D., Baltimore, Maryland.

James F. Kelly, M.D., and D. A. McDowell, M.D., Creighton University Medical School, Omaha, Nebraska.

B. R. Kirklin, M.D., Mayo Clinic, Rochester, Minnesota.

The Jefferson Hospital, Philadelphia, Pennsylvania.

Robert R. Newell, M.D., Stanford University School of Medicine, San Francisco, California.

Bernard H. Nichols, M.D., Cleveland Clinic, Cleveland, Ohio.

George E. Pfahler, M.D., and Jacob H. Vastine, M.D., Philadelphia, Pennsylvania.

A. Howard Pirie, M.D., Royal Victoria Hospital, Montreal, Canada.

Leo G. Rigler, M.D., University of Minnesota, Minneapolis, Minnesota.

Edward W. Rowe, M.D., Lincoln, Nebraska.  
Frank B. Stephenson, M.D., Children's Hospital, Denver, Colorado.

William H. Stewart, M.D., New York City.  
W. Warner Watkins, M.D., Phoenix, Arizona.

Joseph Aspray, M.D., Spokane, Washington.  
Indianapolis, and Indiana University Hospitals, Indianapolis, Indiana.

Children's Hospital, Philadelphia, Pennsylvania.

W. E. Chamberlain, M.D., and Barton R. Young, M.D., Temple University Hospital, Philadelphia, Pennsylvania.

H. H. Cheney, M.D., Ottawa, Canada.

Kenneth S. Davis, M.D., St. Vincent's Hospital, Los Angeles, California.

Edwin C. Ernst, M.D., St. Louis, Missouri.

Amédée Granger, M.D., Charity Hospital, New Orleans, Louisiana.

J. E. Habbe, M.D., Milwaukee, Wisconsin.

Charles H. Heacock, M.D., Memphis, Tennessee.

Robert H. Lafferty, M.D., Charlotte, North Carolina.

Blodgett Memorial Hospital, Grand Rapids, Michigan.

Anders P. Overgaard, M.D., Omaha, Nebraska.

Dorwin Louis Palmer, M.D., Portland, Oregon.

Joseph C. Peden, M.D., St. Louis, Missouri.

E. A. Pohle, M.D., Ph.D., University of Wisconsin, Madison, Wisconsin.

Charles M. Richards, M.D., San Jose, California.

W. T. Rowe, M.D., Rumford, Maine.

Wilbur O. Upson, M.D., Leila Hospital, Battle Creek, Michigan.

It was agreed beforehand that any or all of the films are to be available for exhibit at the next meeting of the Radiological Society of North America in December. Some of the panels are quite simple and rudimentary, while others are of such character as to interest the advanced student in radiology.

The Chicago Roentgen Society wishes to acknowledge the material aid of the following organizations in making this exhibit possible:

The Radiological Society of North America  
The American Roentgen Ray Society  
The Chemical Foundation

Eastman Kodak Company  
 Westinghouse X-ray Company  
 General Electric X-ray Corporation  
 Standard X-ray Company  
 Picker X-ray Company  
 DuPont Film Mfg. Corporation  
 Buck X-Ograph Company  
 Philips Metalix Corporation  
 George W. Brady & Company  
 Patterson Screen Company  
 H. G. Fisher & Company

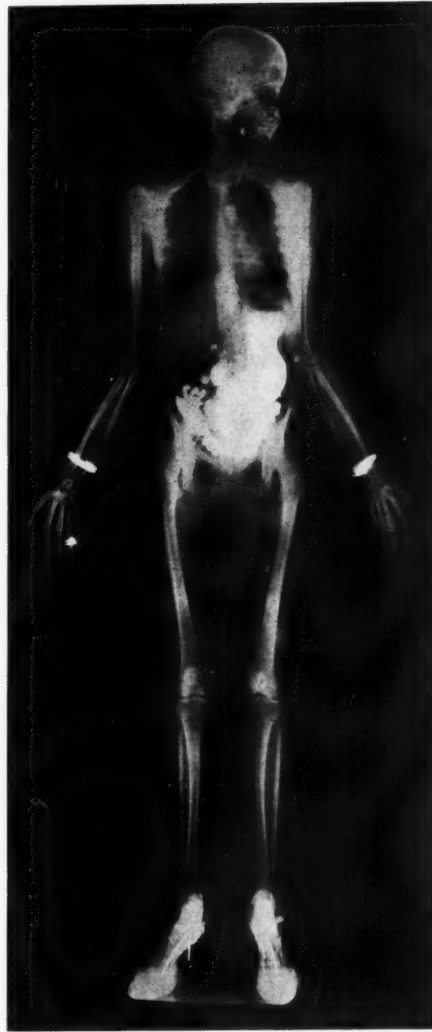
#### A POPULAR DEMONSTRATION AT A CENTURY OF PROGRESS

Herewith is presented a roentgenogram showing the appearance of an entire *living* girl, aged twenty years. The roentgenogram was made with one exposure, employing a single x-ray film 32 by 72 inches in size. This attractive young lady stepped into the x-ray research laboratory of the Eastman Kodak Company and became the subject of a full-length x-ray portrait. The life-size result, taken in one second on what may be the largest film ever used for an exposure, has just gone on view at A Century of Progress, in the exhibit arranged by the Chicago Roentgen Ray Society.

No doubt the young lady would have preferred dinner, but the technician in attendance was compelled to recommend that she ingest a meal of barium sulphate and malted milk so as to delineate roentgenographically the gastrointestinal tract.

This roentgenogram marks a new departure and should provide a means whereby studies can be made of the relationship between the internal organs of the body and posture; of malignant metastases; of multiple fractures and dislocations, and of the sequelæ of metabolic diseases which manifest themselves in alterations of the skeletal structure. Such roentgenograms should also have value in the medical school in teaching vital anatomy to students.

Full-length roentgenograms can be made in most laboratories. In order to obtain an equalization of density over the subject's entire anatomy, selective filtration of the x-rays is made, employing a copper and aluminum filter.



A full-length x-ray portrait.

#### ETHICAL PUBLICITY

Through the co-operation of the Chicago Lighting Institute and the Chicago Roentgen Society a program of education presented to lay persons was given at the Chicago Civic Opera Building during the last two weeks of April. Various members contributed these talks and the total attendance was over three thousand.

Numerous civic and educational bodies were invited, some of which were branches of Ro-

tarians, Lions, and Kiwanis Clubs; students from Lewis Institute, Armour Institute, and Chicago Technical School.

Radiology lends itself so admirably to publicity that when opportunity affords, it should be accepted. It is hoped to arrange similar events in the succeeding years.

### RESOLUTIONS<sup>1</sup>

The following Resolutions were introduced before the American Medical Association, at the Cleveland Session, in June, 1934. Dr. Soiland and Dr. Fisher may be sure that a great body of radiologists share their views.

#### RESOLUTIONS ON EXPLOITATION OF ROENTGENOLOGISTS IN HOSPITALS

Albert Soiland, M.D., of Los Angeles, presented the following resolutions:

WHEREAS, It has been reported to the officers and members of the Section on Radiology of the American Medical Association that an intolerable condition exists between certain otherwise acceptable hospitals and their departments of radiology, and

WHEREAS, It is known that in several such hospitals the business management does the collective bargaining for x-ray business with staff members and outsiders to the detriment and professional and financial loss of their staff roentgenologists, and

WHEREAS, Such practice is not only unethical but places such hospitals on a direct competitive medical practice basis with their respective roentgenologists, which practice has been declared illegal in several States, and

WHEREAS, The practice of roentgenology or radiology is *ipso facto* the practice of medicine and cannot be separated therefrom, be it therefore

*Resolved*, That the House of Delegates of the American Medical Association go on record as opposing the exploitation of members of their own body in the manner outlined; and be it further

*Resolved*, That the House of Delegates of the American Medical Association in session duly assembled orders this resolution to be referred to the Council on Medical Education and Hospitals for the study and formulation of plans tending to the abatement of these highly unprofessional and obnoxious evils.

<sup>1</sup> Reprinted by permission of Journal of the American Medical Association, June 23, 1934, 102.

#### RESOLUTION AUTHORIZING SECTION ON RADIOLOGY TO INVITE FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY TO BE HELD IN AMERICA

WHEREAS, The International Congress of Radiology, which convenes every three years, has already had three such meetings abroad: in London in 1925; in Stockholm in 1928; in Paris in 1931 and now in Zurich in 1934; and

WHEREAS, The radiologists of the United States desire to invite the European radiologists to America for the 1937 International Congress; and

WHEREAS, In the opinion of members of the Section on Radiology of the American Medical Association, such an international meeting would at this time engender a national good feeling and would be of high value to scientific radiology; be it therefore

*Resolved*, That the House of Delegates of the American Medical Association authorize the Section on Radiology to cordially invite the fifth International Congress to be held in America at such time and place as may be decided on by the International Committee of the Fifth Congress of Radiology.

#### RESOLUTIONS BARRING FROM THE PRACTICE OF RADIOLOGY ALL PERSONS NOT LICENSED TO PRACTISE MEDICINE

George M. Fisher, M.D., of New York State, presented the following Resolutions:

WHEREAS, The making of a diagnosis by means of the x-rays and for the administration of x-rays, or other radiant energy for treatment, are methods of diagnostic or therapeutic medical practice, and

WHEREAS, The medical practice act makes the diagnosing and/or treatment of disease unlawful for any one not duly licensed to practise medicine, and

WHEREAS, During the past ten years or more lay persons and lay organizations have established and are conducting x-ray laboratories in which lay persons are examining and/or treating patients by means of x-rays, and

WHEREAS, Such lay persons are not properly qualified and are not subject to effective supervision or control, and

WHEREAS, The x-rays in the hands of inexperienced and/or irresponsible persons are in themselves a potential source of injury to the patient, and

WHEREAS, In addition to these dangers, x-ray diagnosis frequently requires the administration of potent drugs or chemicals which may be legally administered only by licensed physicians, and

WHEREAS, Under these conditions the lay



x-ray operator and the commercial x-ray laboratories constitute a menace to the public and in addition are strictly commercial enterprises conducted by business getters who are actuated by the profit motive and who consequently do not feel themselves bound by the rules of medical ethics but who resort to all sorts of questionable methods to attract a compliant clientele, and

WHEREAS, By the employment of solicitors, runners, and/or other business agents and by the promise of rebates or of favorable or dishonest diagnoses obtain the patronage of unscrupulous physicians or of business and industrial organizations to the detriment of the patient, and

WHEREAS, Because of their illegal activities and the desire for profit they have been unable to attract competent physicians adequately trained in radiology and as a result employ the services of individuals whose education, training, and character are unacceptable to right thinking members of the medical profession or to the American Medical Association, and

WHEREAS, The technical diagnostic and therapeutic advances being made in radiology are due to and dependent on properly trained physicians to whom science must look for further progress in the field of radiology, and

WHEREAS, The lay x-ray technicians and laboratories have so encroached on the practice of radiology that competent and ethical medical practitioners find it more and more unattractive as a field of endeavor, thus endangering the progress and advancement of the science of radiology and the welfare of the public, be it therefore

*Resolved*, That the House of Delegates in convention assembled believes that the practice of radiology, whether for diagnostic or therapeutic purposes, constitutes in fact the practice of medicine, and be it further

*Resolved*, That the properly constituted authorities be called on to take the requisite steps to bar all persons not licensed to practise medicine in the State of New York from the practice of radiology, and be it further

*Resolved*, That, if it is the opinion of the Attorney General that non-medical technicians practising radiology are not violating the law under present conditions, such steps be taken to institute legislation which will include radiology in the practice of medicine and to limit diagnostic or therapeutic x-ray work to the direct and active supervision and control of duly licensed physicians or dentists, and be it further

*Resolved*, That our delegates from New York to the American Medical Association be in-

structed to bring this matter to the attention of the House of Delegates of the American Medical Association at the impending session.

## ACTION RELATING TO NON-MEDICAL RADIOLOGISTS

The medical profession of France is to be congratulated on a new law which requires that a radiologist shall be a graduate physician. Those who have been engaged in radiological work for over thirty years are the only exception. The ruling reads as follows:

*"Radiographers Required to Be Doctors.*—A new law pertaining to the practice of medicine will require the possession of a doctor's diploma in order to practise radiography and radiotherapy. Heretofore the radiographic laboratories in the hospitals have been under the direction of specialists who are not graduate physicians. Their number was small, dating for the most part from the beginning period of the use of roentgen rays. Many of these men had adapted themselves to this work in a remarkable manner. Occasionally, however, examples of fraud in the form of 'trick films,' in connection with claims following occupational accidents, have been discovered. Physicians have for some time shown displeasure at the rôle assumed by non-diplomaed radiographers, whom they have charged with a lack of knowledge of anatomy and with not always knowing what part of the body merited particular attention for the establishment of a diagnosis. With regard to treatment, this constituted, it was pointed out, the illegal practice of medicine and entailed serious risks for the patients. As the result of demands made by the medical syndicates, this regulation was inserted in the new law. Non-diplomaed hospital radiologists appointed more than thirty years ago, and who have won the respect of physicians by the meritorious quality of their services, are to be admitted to registration."<sup>1</sup>

In Europe as in this country, there have been for years non-medical men and women practising radiology, in private laboratories and even in hospitals where, in certain instances, they have been permitted to take charge of the x-ray department. It is a highly dangerous

<sup>1</sup> Paris letter, Jour. Am. Med. Assn., June 16, 1934, 102, 2035.



practice to permit untrained medical persons to use such dangerous agencies as the x-ray and radium in the diagnosis and treatment of disease, and how much more dangerous to permit by law non-medical persons the use of these agencies. There are a few laymen who, through years of experience, have developed a mechanical diagnostic instinct, not based, however, on scientific facts or knowledge of roentgen pathology, which is indispensable to accurate diagnosis and effective therapy. A non-medical technician trained in a pathologic laboratory cannot and does not assume the rôle of a pathologist, even though he has learned to recognize the microscopic appearance of certain abnormal tissues. To permit such individuals to diagnose and treat diseases without a medical education would be an acknowledgment that the years of study required to obtain the knowledge to practise medicine are unnecessary.

At the last meeting of the American Medical Association, in the House of Delegates, resolutions were presented which, if carried out, may give us the same results as the recent French law. To demonstrate that we are in need of this reform, we have only to cite the status of radiology in this country a few years ago.

Until recently, 36 per cent of the State Boards of Medical Examiners of this country did not believe the practice of radiology to be the practice of medicine. A great change has occurred since then, but we believe that there are still some who are of the same opinion. The splendid action taken by the American Medical Association, in recognizing radiology on the same basis as the other specialties, has been of great assistance to organized radiology. We are hopeful that the proper officers of this great medical organization will act favorably on the resolutions introduced in the House of Delegates by Dr. Soiland and Dr. Fisher. Such action by the American Medical Association will discourage non-medical men from entering this field, and will also tend to influence proper legislation in those States which have hitherto been reluctant to act.

The excellent co-operation of all the radiological societies in organizing the first American Congress of Radiology has given a splendid boost; these and other factors account for the increased recognition which radiology has received during the last few years. Another important factor which has helped in elevating the standards of radiology is radiological edu-

cation in medical schools. Four years ago, most medical schools in this country did not require a student to take a course in radiology, though most medical schools then offered short courses. Most of these short courses were elective, either under the radiological department or combined with medical clinics. How different it is to-day! A recent statistical study shows that radiology is given a very liberal allowance of hours. We do not mean that it is sufficient or commensurate to its importance, but, when compared with what was given only a few years ago, the increase in radiological teaching hours is most gratifying.

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#### THE AMERICAN SOCIETY OF X-RAY TECHNICIANS

At a recent meeting of the American Society of Radiographers held at Milwaukee, the name of this organization was changed to the American Society of X-ray Technicians. This change in name, we believe, is a good and wise one. The former name would no doubt in certain instances lead to confusion, while the latter name can hardly be misinterpreted.

The members of this Society are to be commended for their attitude toward the radiological profession. When they heard that there was some opposition to the name "radiographer," they immediately sent out a questionnaire to several hundred radiologists for a frank opinion. When the returns were tabulated, it was found that the sentiment of these radiologists was strongly against the usage of the word "radiographer" and favored a change. The change was made by this organization and their action is but another substantial proof of the desire of its members to co-operate with organized radiology.

There is much in common between the radiologist and the x-ray technician, and often the success of the former is to a certain extent the result of good technical work. There can be no denying the fact that a competent x-ray technician is helpful in enabling a radiologist to enlarge his field of endeavor.

The American Society of X-ray Technicians is doing splendid work. The members are qualifying only competent and experienced technicians, and if any one doubts their earnestness in this regard, he has only to see the type of examinations they give. Both oral and practical examinations are used in qualifying

the applicants, who have been thoroughly investigated, particularly as to their moral character. For this reason the radiological profession should lend every possible encouragement and co-operation to this Society, and one of the important things it can do is to encourage its technicians to qualify before the Society's Board.

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MEMORIAL TO  
PROF. ALBERS-SCHÖNBERG

The fiftieth volume of the well-known journal named "Strahlentherapie," published in Berlin by Urban & Schwarzenberg, has been dedicated to the late Professor Albers-Schönberg, who died from roentgen injuries. Professor Albers-Schönberg, whose home was in Hamburg, was a pioneer German radiologist and the occupant of the first chair established for radiology in a German medical school.

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RADIOLOGICAL SECTION OF THE  
MEDICAL SOCIETY OF NEW  
JERSEY

At the 168th Annual Meeting of the Medical Society of New Jersey June 6 and 7, the Radiological Section presented the following program:

Suppurative Hip in Children, G. Herbert Taylor, M.D., East Orange. Discussant: Harold Smith, M.D., Orange.

Protracted External Radiation in the Treatment of Neoplasms of the Upper Respiratory Tract, Milton Friedman, M.D., Newark. Discussant: Elwood Downes, M.D., Woodbury.

Report of a Case of Foreign Body in the Esophagus, Erwin Reissman, M.D., Newark.

Lung Changes Subsequent to Irradiation in Breast Cancer, Elwood Downes, M.D., Woodbury.

Intrathoracic Anatomy from the Roentgenologist's Standpoint, William Wallace Maver, M.D., Jersey City.

Why Gastric Cancers Show Characteristic Roentgen Findings, Lewis G. Cole, M.D., New York City.

Osteogenic Tumors, John Tidaback, M.D., Summit, and A. F. Galasso, M.D., Morristown. Discussant: F. H. Pinckney M.D., Morristown.

The Problem of Silicosis—A Practical Viewpoint, Raphael Pomeranz, M.D., Newark.

Roentgen Diagnosis of Lesions of the Esophagus, Charles F. Baker, M.D., Newark, and W. James Marquis, M.D., Newark.

Report of a Case of Mediterranean or Sickle-cell Anemia, Austin Vogel, M.D., Elizabeth.

The Recognition of Some Forms of Intracranial Pathology, Charles W. Schwartz, M.D., New York City.

Elwood Downes, M.D., of Woodbury, was elected Chairman for the coming year.

## BOOK REVIEWS

**PRACTICAL X-RAY THERAPY.** By HUGH DAVIES, M.A. (Oxon.), M.R.C.S. (Eng.), D.M.R.E. (Camb.), officer in charge of x-ray therapy, King's College Hospital; Honorary Assistant Radiologist, National Hospital, Queen Square. First edition. Cloth. A volume of 134 pages with 47 illustrations. J. and A. Churchill, London, 1934. Price, 8 shillings and 6 pence.

This little book is intended to present the elements of x-ray therapy to the radiologic student and to acquaint the general medical student with the importance of x-ray therapy, a subject which is ever expanding into the fields of medicine and surgery. The presentation is essentially practical and not technical and covers the subject in a fluent, lucid, and, in fact, rather entertaining way. The indications for x-ray therapy, the technic of treatment, and the results to be obtained are outlined in a sound and conservative manner so that a firm foundation is laid for the reader to carry out effective x-ray treatment. The reviewer knows of no easier introduction to radiotherapy than that presented by the author.

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**MODERN FINSSEN TREATMENT.** DR. SVEND LOMHOLT, Director of the skin clinic of Finsen Institute, Copenhagen. A volume of 64 pages and 52 illustrations. Published by Urban & Schwarzenberg, Berlin, 1934. Price not stated.

This is a reprint of an article which appeared originally in "Strahlentherapie," 1934, 49, 1, concerning the indications for and the results to be expected from Finsen light therapy. One observation of significant interest to the radiologist is that late x-ray reactions, *i.e.*, atrophy, telangiectasis, ulcers, are often benefited by proper Finsen treatment.

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**NASAL ACCESSORY SINUSES.** FREDERICK M. LAW, M.D., Roentgenologist, Manhattan Eye, Ear and Throat Hospital, New York. Volume 15 of Annals of Roentgenology, edited by James T. Case, Professor of Roentgenology, Northwestern University

Medical School, Chicago. The volume contains 197 roentgenologic (215 pages) studies, 28 clinical illustrations, and 3 key plates. Published by Paul B. Hoeber, Inc., New York, 1934. Price, \$10.

This is a practical treatise concerning the roentgenologic diagnosis of accessory sinus disease that will be welcomed by all concerned with the subject. The author has approached the matter from the standpoint of both the roentgenologist and rhinologist, and the text reflects his large experience in each field. For the roentgenologist, there is emphasized the character of information to be gained from roentgenograms that would be of help to the surgeon in the event of operative procedure. For the rhinologist, the extreme value to be obtained from a comprehensive knowledge of the anatomy revealed, especially on stereoscopic films, is stressed.

There is an excellent description of the various technical procedures, and all the usual positions for examination are well illustrated. For routine examination the author derives the greatest information from the use of the Caldwell (nose-forehead) and stereoscopic lateral positions. Other positions are taken as indicated. It is to be noted that Dr. Law prefers to use a vertical or inclined vertical x-ray beam, instead of a horizontal one which frequently depicts the level of fluid and pathologic changes that might be obscured by it. In his opinion, the presence or absence of fluid is readily ascertained by clinical means.

The chapters on diagnosis and interpretation are excellent expositions of the information that may be gained from an intelligent study of good roentgenograms of the sinuses. The significant point is that in most instances this information may be obtained by the application of the simple and practical technic described by Dr. Law, without the use of elaborate or expensive apparatus. Concerning the use of opaque materials injected into the sinuses, the author states that "for surgeons who do not want to inspect films carefully or who want to demonstrate a chronic cavity on lantern slides, the injection method is very satisfactory, but otherwise a diagnosis can usually be made without this method." Most

experienced roentgenologists will agree with this.

The numerous illustrations (225) are deserving of commendation because of the detail and clarity that have been maintained in spite of the difficulty of reproducing roentgenograms of this type. The topography and arrangement of the text are excellent.

**X-RAY AND RADIUM INJURIES: PREVENTION AND TREATMENT.** By HECTOR A. COLWELL, M.B., Ph.D., M.R.C.P., D.P.H., and SIDNEY RUSS, C.B.E., D.Sc., F. Inst. P., the Barnato Joel Laboratories, Middlesex Hospital. Cloth, pp. 212, with two illustrations. Oxford University Press, Humphrey Milford, London, 1934. Price, \$4.75.

The importance, in fact the absolute necessity, of a radiologist having a thorough knowledge of the effects of radiation on normal tissues and of the dangers inherent in the use of the physical agents cannot be over-emphasized. With the ever-expanding uses of radium and roentgen rays in the fields of diagnosis and treatment, unfortunately too often it may well happen that patients will be encountered who are suffering from injury sustained long previously or from severe recent improper radiation at the hands of those with but meager experience and training. Also, the radiologist, either from ignorance or carelessness, meanwhile may have sustained irreparable injury to himself. Until the advent of this book there was no text in English which adequately analyzed the effects of radiations on the various tissues of the body, and even though this book is not intended to be an exhaustive treatise on the subject, it will probably be for some time to come the standard reference book concerning it. More important perhaps than the description of the pathologic changes induced in normal tissues by radiations both under clinical and experimental conditions is the inclusion of recommendations for protection against injury. Humphrey Rolleston voices the sentiments not only of the British x-ray and radium protection committee, but of radiologists throughout the world when he remarks in his foreword: "We are proud to be allowed to welcome the appearance of such a monumental proof of the need for precautions."

In this reviewer's opinion the book should be owned and read repeatedly by all radiologists and all students of radiology.

**ROENTGENOSTEREOSCOPY (Das Röntgenraumbild).** DR. WERNER TESCHENDORF, Chief Physician of the Radiologic Institute for General Ortskrankenkasse, Köln, and Privatdozent at the University of Erlangen, and DR. HANS KÖHNLE, roentgenologist of the Internal Medicine Clinic of the Medical Academy, Düsseldorf. A volume of 173 pages and 126 illustrations. Published by Urban and Schwarzenberg, Berlin, Germany, 1933. Price (paper) RM 9, and (bound) RM 10.50.

In this monograph the authors discuss the theoretical and technical optical fundamentals of stereoscopic vision as regards its roentgenologic aspects. The structural and stereographic peculiarities of the roentgenostereoscope are discussed in detail, with a consideration of representative types of apparatus. The significant sources of error are indicated and suggestions given as to how to utilize the method to its greatest advantage.

There is an extensive bibliography. Because of the comprehensive and practical manner in which the subject is presented, this book should be of interest to all roentgenologists and others who are interested in the everyday use of this important procedure.

This monograph also appears under the title "Die Röntgenstereoskopie" in Abderhalden, *Handbuch der biologischen Arbeitsmethoden*, Abt. II, Teil 3 (Lfg. 408).

**FOREIGN BODY IN AIR AND FOOD PASSAGES.** By CHEVALIER JACKSON, M.D., Sc.D., LL.D., F.A.C.S., Professor of Bronchoscopy and Esophagoscopy, Temple University, and CHEVALIER L. JACKSON, M.D., M.Sc. (Med.) F.A.C.S., Professor of Clinical Bronchoscopy, Temple University, Philadelphia. Volume 16, *Annals of Roentgenology*. Edited by James T. Case, M.D., Professor of Roentgenology, Northwestern University Medical School, Chicago. A volume of 265 pages, with 236 roentgen-ray studies and 10 clinical illustrations. Published by Paul B. Hoeber, New York, 1934. Price, \$12.00.

In keeping with a style frequently used by the senior author the "message" in this monograph is portrayed by axioms and illustrations, most of the latter being roentgenograms. It is emphasized that foreign bodies, if undiscovered, sooner or later prove fatal, whereas if the diagnosis is promptly made the foreign body can be removed by endoscopy through the

mouth and the patient cured in 98 per cent of the cases. With this in mind the subject has been treated from the viewpoint of how the roentgenologist can be of the utmost help to the endoscopist. It has been assumed that the reader has a fundamental knowledge of the science of roentgenology and roentgenologic anatomy. The valuable information and suggestions that are embodied in the axioms and legends of the numerous illustrations reflect the meticulous care that must be used in studying cases of this sort and which is so necessary to a successful consummation of the problem at

hand. It is to be regretted that greater credit has not been given to the authors' roentgenologic colleagues who have done much to develop the roentgenologic foundations upon which modern oral endoscopy is so dependent.

The scope of this book and its value to the roentgenologist might have been considerably increased if a section concerning the subject from the standpoint of a roentgenologist had been added. Nevertheless, experienced roentgenologists will appreciate the lessons unfolded by this work and the novice will profit much by it.

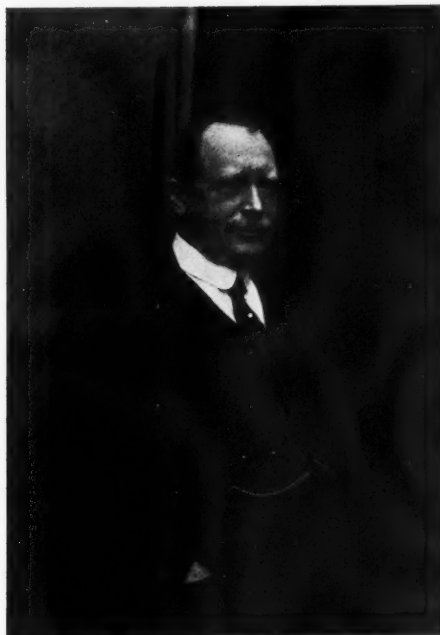
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## IN MEMORIAM

### CARLOS HEUSER

Dr. Carlos Heuser, an international figure in radiology, died in Buenos Aires on March 28, 1934, at the age of fifty-six. He was born in Buenos Aires and pursued his primary and secondary studies in that city. He graduated from the medical school in 1902, his thesis having been awarded the gold medal. From that early date he dedicated himself to the study of radiology. He contributed many improvements to its technic and wrote many articles—published, for the most part, first in the "Prensa Medica Argentina," as well as several books on radiology. Among these were a practical treatise on radiology and superficial and deep radiotherapy for which he received the prize of the faculty of medicine of Buenos Aires. He also wrote a book on the use of the x-ray in gynecology, obstetrics, and urology; numerous articles on arteriography, hepatolienography, amniography, intravenous pyelography, and many articles on hydatid cysts both from the standpoint of diagnosis and treatment, also on the diagnosis of pregnancy in the early months by means of the x-ray, etc. Dr. Heuser took part in numerous international congresses, and in 1930 received the gold medal of the Radiological Society of North America. He was a corresponding member of the American Roentgen Ray Society, and an honorary member of the American



The Late Carlos Heuser, M.D.

College of Radiology. Apparently, Dr. Heuser was the first to use lipiodol for uterosalpingography, having accomplished this in 1921. A full report of this work was made in 1924 for Dr. Heuser by the writer, at the Latin-American Scientific Congress, in Lima.

JAMES T. CASE, M.D.

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## ABSCESSSES

Treatment of Acute Pulmonary Abscess. S. U. Marietta. Jour. Am. Med. Assn., April 28, 1934, 102, 1363-1368.

This discussion has to do with single (including multi-locular) abscesses and does not include those due to tuberculosis, bronchiectasis, and new growths. The treatment of all acute cases is medical until it becomes evident that such treatment will not succeed. The period of medical treatment varies from six to twelve weeks. Physical examination and roentgenograms are of great assistance in decision for surgery; collapsibility increases with the distance of the lesion from the pleura. When the visceral and parietal layers of pleura become adherent, elimination of the cavity by contraction becomes difficult. The etiologic factors have directly to do at times with the form of treatment to be undertaken. Aspiration from a foul mouth may be a cause—early treatment with arsenical preparations has controlled this type. Commonly streptococci (rarely pneumococci) bronchopneumonia, aspiration of a foreign body or septic material, and septic emboli are the factors. Over half the cases respond to conservative measures. The elimination of a chronic lung abscess by medical treatment alone is not to be expected.

C. G. SUTHERLAND, M.D.

## APPARATUS

Electrical Phenomena in High Tension Circuits of Roentgen Apparatus. G. Grossmann. Fortschr. a. d. Geb. der Röntgenstrahlen, 1933, 48, 450-474; 1934, 49, 1-31.

The introduction describes the capacitive relationship of the high tension system of a roentgen installation to its grounded parts. In ungrounded apparatus this refers particularly to the capacities existing between the secondary windings of high tension and filament transformers and their low tension sides. In shock-proof installation one has to consider, in addition, the high capacities of the cables.

Capacities of half-wave apparatus are distributed asymmetrically; consequently their potentials also are

distributed asymmetrically. The influences of capacities and conditions of insulation upon height and phase of potentials existing between the terminals of a transformer and ground are demonstrated mathematically. Furthermore, the influence of the capacity of the side of a transformer, separated from ground by a half-wave rectifying kenetron tube, upon the potential of this terminal to ground is demonstrated. This capacity, comprising in a shock-proof installation with half-wave kenetron rectification, one filament transformer and one cable ("terminal capacities"), is changed during the working phase, during which period damped medium and high frequency oscillation develop, and then discharged through the roentgen tube.

Diagrams illustrate the fluctuations of potentials at the roentgen and kenetron tubes under varying conditions of output. Influences of the capacities mentioned upon phenomena in the primary transformer-circuit are discussed and the currents passing through a person touching one high tension terminal are calculated.

In the second part of this paper the voltage curves of fully valve-rectified and also of condenser-equipped apparatus are introduced. Only in the Liebenow circuit can one regard terminal capacities as a desirable addition to the energy-storage for activation of the roentgen tube. They are decidedly disadvantageous in non-shock-proof apparatus with kenetron half-wave rectification, in the Villard type machines, and those with triplication of potentials; they are of no consequence in full wave rectification. Cables of shock-proof apparatus have to withstand electrical stresses in proportion to amplitude and frequency of potentials applied.

The paper is profusely illustrated and will be of great interest to all those familiar with detail of construction of roentgen apparatus and the problems of the various circuits and of shock-proofing.

H. A. JARRE, M.D.

## ARTHRITIS

The Relation of Trauma to Arthritis. Howard P. Doub. Am. Jour. Roentgenol. and Rad. Ther., July, 1933, 30, 26-33.

Injury of sufficient severity to produce damage to cartilage is often followed by chronic tissue changes called "traumatic arthritis," although the writer would prefer the term "chronic traumatic joint reactions." There is considerable difference of opinion as to the exact mechanism which enters into the development of joint changes in chronic hypertrophic arthritis. Some believe the underlying pathology is in the nature of a localized arteriosclerosis producing a state of ischemia, but others believe the condition one of hyperemia persisting for ten days or longer, following trauma. Axhausen concludes that cartilage necrosis with the presence of devitalized cartilage in the joint is the cause of arthritis. Fisher, on the other hand, attributes the changes of osteo-arthritis to prolonged or often repeated injury, either mechanical or toxic, but of moderate intensity. In cases in which trauma is often repeated it may be the direct etiological factor, but if there has been only a single contusion, it is apt to be only a predisposing cause.

The earliest joint changes demonstrable in a joint following trauma were those in a knee six weeks after injury to a proven normal part; however, the average interval is three to six months and it may take years.

Hypertrophic arthritis tends to be generalized, while traumatic arthritis is usually limited to one joint. However, the x-ray appearance of hypertrophic arthritis and traumatic arthritis may be quite similar in any given joint, hence the history and physical findings are necessary for differentiation.

In a clinic referred to by the author, in a series of 124,000 cases with the same type of injury, a relation between trauma and hypertrophic arthritis was established in only eighteen.

Criteria for establishing a diagnosis of traumatic arthritis should include the following: (1) proof of sufficiently severe injury to damage joint cartilage; (2) injury must have been direct to the joint in question; (3) knowledge of previous function of joint must be available; (4) the time interval between injury and development of joint changes must be within accepted limits, and (5) there must be clinical and roentgenological evidence of pathologic tissue changes.

J. E. HABBE, M.D.

### BONES (DISUSE)

The Effects of Immobilization on Normal Bone. Francis M. Conway and John G. Stubenbord. *Jour. Bone and Joint Surg.*, April, 1934, 16, 298-302.

The authors studied the effects of immobilization on normal, healthy, uninjured bone by means of the roentgen ray to determine whether immobilization alone was responsible for the atrophy and osteoporosis seen on the x-ray film of fractured bones which had been immobilized for a period of from ten to fourteen days. Wolff's law states, "All changes in the function of a bone are attended by definite alteration in the internal structure." As a result, one would expect atrophy of a part through disuse.

It has been generally noted that, following injury to a bone, osteoporosis results in the bone. This is caused by the decalcification or the absorption of the lime salts. While the cause of decalcification is not thoroughly understood, it is believed to be due to a change in the metabolism of the bone resulting from the injury, because of interference with the circulation. The usual roentgen signs of these changes in bone consist of: (1) decrease in the density of the bone, (2) thinning of the cortex, (3) apparent widening of the medullary canal.

In this study the authors selected only normal, healthy individuals—patients who were forced to remain in the hospital because of accidental injury, and those who had some definite complaint of short duration but whose general health was excellent. Cases of asthma, bone diseases, chronic constitutional diseases, diseases in which there were circulatory disturbances, chronic hyperthyroidism, parathyroid disease, and pregnancy were considered unsuitable for this study and were not so employed. No effort was made to regulate the diet of these patients in any manner. There were no blood-calcium content investigations included in this study. All roentgenograms were made by the same technician on the same machine, with all technical factors constant.

The wrist and forearm were selected as the most suitable bones for this study, with the exception of one case in which the knee was immobilized. Roentgenograms were made of both wrists and forearms in anterior, posterior, and lateral positions at the beginning of the study. Then one wrist and forearm was immobilized by means of anterior and posterior plaster-of-Paris splints held by a bandage. The length of immobilization varied from seven to twenty-four days. At the end of the period of immobilization roentgenograms were again made of both wrists and forearms in the same positions previously employed. In no case were any bone changes noted as a result of immobilization. The authors, therefore, concluded that, in the absence of injury, there are no signs of atrophy in normal, healthy bones through disuse *per se* during a period ranging up to three weeks, so far as may be observed from the roentgenograms.

J. N. ANÉ, M.D.

### BONE DISEASES (DIAGNOSIS)

Periostitis of the Os Calcis. C. C. Chang and Leo J. Milner. *Jour. Bone and Joint Surg.*, April 1934, 16, 355-364.

The authors discuss the etiology, pathology, diagnosis, and treatment of periostitis of the os calcis. This condition is characterized by a deposition of lime or a proliferation of bone on the surface of the os calcis, chiefly near the sites of origin of the plantar fascia and the insertion of the Achilles tendon.

The etiologic factors described are as follows: (1) gonorrhea; (2) trauma; (3) arthritis; (4) streptococic foci of infection; (5) metabolic disturbances; (6) syphilis; (7) arteriosclerosis, tuberculosis, and (8)



neurotrophic disturbances. Infection and trauma are considered the most important of these factors.

Pathologically, the first signs to be noted consist of a low-grade chronic inflammation as shown by thickening and edema of the periosteum, proliferation of fibroblasts, and round-cell infiltration. Subsequently, lime deposits occur beneath and outside the periosteum in the regions of the insertions of the tendon and fascia. In the advanced cases, microscopic examination of sections of bone shows fibrosis of the marrow tissues, small areas of necrosis, hyaline degeneration, proliferation of fibroblasts, and sclerosis of the cortical bone.

Pain and tenderness over the affected area are considered the symptoms of most importance. The pain, which may be dull or sharp, constant or intermittent, is first noted only during walking. The small, sharply defined spur usually causes piercing pain, while the more extensive periostitis results in dull, aching pain. Swelling over the inflamed area is seen in the more advanced cases.

The diagnosis of this condition depends upon the roentgen-ray examination, which also determines accurately the area of involvement and stage of development. This method of examination likewise offers the only means of differentiating periostitis of the os calcis from arthritis, arch strain, osteoma, and lesions of the medullary portion of the bone. While this condition usually occurs in adult life, in rare cases it is noted during adolescence and then it should not be confused with apophysitis which is an involvement of the posterior inferior epiphysis. In the latter disease, roentgenograms show irregularity, clouding and obliteration of the cartilage plate of the epiphysis.

The treatment of periostitis of the os calcis may be non-operative or operative. The authors are of the opinion that every case should be first treated conservatively. The non-operative form of therapy consists of attempts to eliminate the etiologic factors and the institution of rest and local applications to relieve the pain. The operative treatment consists of the removal of spurs, and the denudation of the roughened areas of periostitis.

J. N. ANÉ, M.D.

**Tuberculosis of the Shaft of Long Bones: Report of Six Cases.** George W. Vangorder. *Jour. Bone and Joint Surg.*, April, 1934, **16**, 269-283.

The author reports a series of six cases of tuberculosis of the shaft of the long bones and discusses the clinical, pathologic, and roentgenologic characteristics and the treatment of this condition.

With rare exceptions tuberculosis of the shaft of the long bones occurs in the earlier years of life, as shown in the author's series, in which the ages of the patients ranged from nine to twenty-one years. The clinical features of the disease are manifested by: (1) local thickening of the affected bone; (2) pain; (3) muscular wasting; (4) abscess formation; (5) sinus formation in the late stages. The appearance of the affected bone in this condition is not characteristic and may simulate any thickening of bone such as is found in

pyogenic osteomyelitis, syphilis, or neoplasm. As a rule, however, the enlarged shaft is not noticeably tender to pressure and there is no increased local temperature or redness until the formation of soft-part abscesses. Pain is an exceedingly variable symptom. It may be marked, slight, or absent. This has been explained as due to the variation in interosseous tension, which is found in the various stages of the disease. Muscular wasting is not as common in tuberculosis of the shafts of the long bones as in tuberculosis of the joints. Abscess formation as a result of local softening and caseation within the bone is a characteristic feature. Sinus formation is seen only in the late stages of the disease when the bone abscess has extended into the soft parts and worked its way to the surface of the skin. As a rule, there is no fever and no leukocytosis, and the general health is not greatly disturbed.

Any portion of the shaft of a bone may be involved by the tuberculous process and the characteristic pathologic feature is the formation of an abscess. This abscess formation results in a definite reaction by the surrounding bone structures, which is more marked in the diaphysis than in the metaphysis. The subsequent course of the bone abscess may be: (1) to remain encysted; (2) to spread along the marrow cavity; (3) to extend from medulla to periphery and invade surrounding soft parts; (4) to extend from metaphyseal focus into the epiphysis and then into a joint.

Roentgenologically the characteristic features of tuberculosis of the shaft of long bones are the central origin of the focus, the abscess formation, and the lack of sequestrum formation. The reaction of the surrounding osseous tissue to the abscess varies in different portions of the shaft. In the metaphyseal portion of the bone, little or no reaction is noted either in the periosteum or in the region of the adjacent bone lamellae. However, in the diaphyseal region the periosteal and lamellar reaction about the tuberculous focus is very marked. Of interest is the fact that while no apparent expansion of the shaft is noted in the metaphysis, when the focus is located in the diaphysis one of the outstanding features is the local expansion of the shaft. This characteristic local expansion of the bone helps to differentiate the lesion from Brodie's abscess and from simple bone cyst, while giant-cell tumor may be ruled out on the basis of its rare occurrence in the mid-portion of long bones.

The treatment employed in these cases consisted of subperiosteal excision of the bone abscesses, which resulted in complete cure in all of the cases except one, in which no end-result was obtained.

J. N. ANÉ, M.D.

**Osteochondritis, Focal and Multiple.** Maxwell Harbin. *Am. Jour. Roentgenol. and Rad. Ther.*, June, 1933, **29**, 763-765.

The true etiology of this condition remains unsolved, due in large measure to the lack of pathologic material from which to draw conclusions. While many cases



show involvement of only one growth center, other cases show multiple involvement, and the condition has been found to be present in several members of one family, hence the author considers it probable that more than one etiologic agent may be a factor. The theory of trauma with disturbance of blood supply has seemed likely in many instances, but it is not consistent with the histologic picture of increased vascularity seen in most cases. Similarly the infection theory is not supported by positive cultural findings in many cases. During the period before this condition was established as a disease entity many patients were considered to have tuberculous joint disease; fortunately, because of the differential aid offered by the roentgen ray, such mistaken diagnosis is rarely made now.

J. E. HABBE, M.D.

### CANCER (DIAGNOSIS)

Cancer, with Special Reference to Early Diagnosis. Roy Ward. *British Med. Jour.*, May 19, 1934, No. 3828, 881-884.

The author analyzes the statistics of the mortality rate of cancer in the British Empire and discusses the importance of early diagnosis and proper treatment, with suggestions for a policy of public education.

In the year 1912, 37,323 persons died from cancer of all types; in 1922, this increased to 46,903 deaths, and in 1932, 60,716 deaths occurred as a result of cancer. While it may be argued that this increase during the twenty-year period resulted from better methods of diagnosis, which revealed more cases of internal cancer, the statistics for breast carcinoma, which is quite obvious in the later stages, would indicate an actual increase in the number of cancer deaths. The statistics for deaths from cancer of the breast only are as follows: 1912, 3,756; 1922, 4,868, and 1932, 6,435.

The estimation of the present methods of treatment of cancer is extremely difficult because of the impossibility of obtaining comparable statistics on a reasonably large scale. It is believed that while surgery has about reached the pinnacle of accomplishment, it will always be the method of choice in certain types of cancer. In the case of radium and x-rays, experience during the last thirty years would indicate that much more will be done with these two agencies and that progress is slowly but surely being made. It is considered of the greatest importance that surgery and radiation should not be divorced. In order that the greatest benefit may be obtained from all three methods of treatment the author suggests the following: (1) decision of its own cancer policy by the members of the staff of every hospital treating cancer; (2) a system for tracing the subsequent history of every case of cancer treated to determine the value of the method or methods employed; (3) uniform records of cancer cases; (4) comparable statistics, and (5) co-operation between institutions and centers treating cancer.

The significance of the early diagnosis and treatment of cancer should be made known to the general public in somewhat less dramatic form than widespread dissemination of warnings, which will only encourage cancerphobia. It is suggested that the health column of the daily press be employed for the purpose of educating the public as a whole in regard to the cancer problem. Another method of serving the public interests would consist of free periodic examinations.

The author suggests the establishment throughout the country of a number of centers devoted to deep x-ray and radium beam treatment. Each center would have a definite policy, which should be known to the other centers in order to prevent overlapping. The function of the medical men outside of the centers would be to supply the various units with the type of case required, and later to assist in following up the patients.

J. N. ANÉ, M.D.

### CANCER (THERAPY)

The Significance of a General Disposition of the Organism for the Development of Cancer and the Possibilities of its Treatment. B. Fischer-Wasels. *Strahlentherapie*, 1934, 50, 5-78.

This article presents a critical review of the literature dealing with the relation between disposition to cancer and cancer therapy. The author and his associates have done considerable experimental work along these lines and the essay is well worth study in the original. He states in the conclusion that his efforts will well be compensated if his clinical colleagues recognize more the importance of the systemic phase of cancer therapy. A most complete bibliography is appended.

ERNST A. POHLE, M.D., Ph.D.

Studies Concerning the Influence of Therapeutic Radium and Roentgen Irradiation on Blood Cholesterol and on the Liver. Kurt Fuge. *Strahlentherapie*, 1934, 50, 157-166.

The blood of 31 women with cancer was studied before and after radium and roentgen therapy. It appeared that the blood cholesterol was not increased as compared with normal controls. In some cases there was a decrease and in some an increase of the cholesterol immediately after irradiation. No evidence of an injury of the parenchyma of the liver could be detected with the methods used by the author.

ERNST A. POHLE, M.D., Ph.D.

### CONTRAST MEDIA

Visibility of Pulmonary Vessels (Angiopneumography). Lopo de Carvalho and Egas Moniz. *Acta Radiol.*, 1933, 14, 433-451.

After numerous experiments on rabbits, dogs, and monkeys, the authors have succeeded in visualizing the pulmonary vessels in man. The process consists in the injection, into the right auricle of the heart, of a highly concentrated (120 per cent) solution of sodium

iodide. The auricle is reached by means of a roentgen-opaque probe, which is introduced into one of the cubital veins, its gradual advance being followed, radioscopically, on the screen. The probe has been sterilized beforehand, and kept in a sterile (10 per cent) solution of sodium citrate. Simultaneously with its introduction, small quantities of physiologic serum are injected by means of a syringe fitted to its other end in order to make the progress easier and prevent the formation of any blood-clot within the tube.

When the probe has been introduced, the roentgen apparatus is made ready for the taking of the roentgenograms, and the cassette is placed against the anterior side of the patient's thorax. The syringe used for the physiologic serum is now exchanged for another, containing the sodium iodide solution. The patient is told to take a deep inhalation, after which he must remain absolutely motionless. The opaque solution is then injected as rapidly as possible, the injection being stopped as soon as from 6 to 8 cm. has been introduced. The syringe is then once more exchanged for the one that contained the physiologic serum, in order to withdraw from the probe the sodium iodide solution that might remain in the latter, and finally also the probe itself is gently withdrawn.

The patients subjected to this angiopneumographic examination do not experience any discomfort worthy of note from the operation. At most, there may be a brief spell of coughing when the injection is finished, and sometimes a slight headache, which, however, soon disappears. To prove the value of the visualization of the pulmonary vessels it suffices to compare, in each individual case, the plain roentgenograms with the corresponding angiopneumograms. The study of the two seems to evidence the scientific importance of this new process, as a means of roentgenographic interpretation in cases of pulmonary lesions.

J. E. HABBE, M.D.

### THE EYE

Apparatus for Reading with Closed Eyes. A. H. Pirie. *British Jour. Radiol.*, February, 1934, 7, 111-116. Reprinted by permission from *British Med. Jour.*, May 26, 1934, page 83 of the *Epitome of Current Medical Literature*.

The author describes an apparatus which enables the patient to see with closed eyes by the use of x-rays. A complete x-ray outfit apparatus is used with an eyepiece, behind which is a transparent wheel having on it mounted lead letters forming words. These can be read through closed lids, since the x-rays are perceptible by the retina. Among the possible uses listed by the author are the following. A patient with a foreign body in his eye can see it, locating it in two dimensions and with moderate accuracy in the third. Damage to the retina caused by a foreign body can be located by the patient. He can also distinguish between these two contingencies, and it is suggested that he might be able to detect a foreign body lying behind the eye, the rays being passed through the

skull to the retina from behind. The condition of the retina can be ascertained in a case of complete cataract. The field of vision can be mapped out by the patient, and minute scotomas localized at once. A foreign body lying laterally to the retina can be made to cast its shadow on the near side and on the far side of the retina, and the patient can thus be enabled to see two shadows—proving that the foreign body is outside the globe. The patient cannot recognize his own blind spot, as it is lost in the brilliant field of light which is seen.

Pirie states that an examination lasting two minutes is quite safe, and well below epilation dose. A time switch, which runs for ten seconds, reminds the examiner of the quantity of rays entering the eye. In order to locate a foreign body or scotoma, or to map out the field of vision, a lead diagram, consisting of a cross with a perpendicular and a horizontal arm, is placed in front of the eye. This casts its shadow on the retina, dividing it into four quarters. The patient describes what he sees in each quarter. If a foreign body is present, casting its shadow into the upper and outer quadrant, the observer reports it in the inner and nasal quadrant. Finer subdivision for localization is obtainable by using a star with eight arms, and by having a lead circle, or even two concentric lead circles, to measure the distance from the center of the retina. The depth of a foreign body from the front of the cornea can be roughly estimated by its change of apparent position when oblique rays are cast on the retina. It is suggested also that glass fragments might be localized by the fluorescence they set up in x-rays.

### FOREIGN BODIES

Foreign Bodies in the Urinary Bladder. W. P. Garshwiler, A. F. Weyerbacher, and James F. Blach. *Am. Jour. Surg.*, November, 1933, 22, 199-202.

Five cases of foreign body in the urinary bladder are herein reported, three of which were introduced to produce sexual excitement, one to produce abortion, and one following a surgical injury to the bladder. Three of the foreign bodies were removed cystoscopically, one by suprapubic cystostomy and one by external urethrotomy.

DAVIS H. PARDOLL, M.D.

### FRACTURES

Inadequate Immobilization and Non-union of Fractures. R. Watson Jones. *British Med. Jour.*, May 26, 1934, No. 3829, 936-939.

While the old form of treatment of fractures consisted of excessive immobilization of joints which too frequently resulted in crippling disabilities, there has been noted a modern trend of undue enthusiasm in the mobilization of joints which results in the improper immobilization of the fracture. The essential principle of modern treatment is complete immobilization of the fracture, with, at the same time, active movement of every joint which need not be immobilized. The

author believes that the many theories of inadequate blood supply, impaired nutrition, inaccurate apposition of fragments, failure of impaction, the inhibitory action of synovial fluid, and the absence of blood clot are of no real significance. The only important cause of non-union is inadequate immobilization.

It was formerly erroneously believed that decalcification of infected bone resulted from an increased blood supply, while the decalcification of fractured bone was due to an impairment of the blood supply. It has been proved that hyperemia of bone always results in decalcification, regardless of the cause of the increased blood supply. Increased calcification, or sclerosis, on the other hand, is the result of impairment of blood supply, as may be seen in Charcot's disease.

In fractured bone the initial traumatic hyperemia gives rise to decalcification of the bone ends. When this hyperemia subsides calcium salts are deposited in the young connective tissue which has grown between the bone ends to form callus. When, in the final stages, the blood supply becomes impaired, the callus undergoes dense calcification, with consolidation of the union. Improper immobilization results in the tearing of the young connective tissue between the fragments. These repeated injuries to the fractured region result in constantly recurring hyperemia, with increased decalcification of the bone ends. When the stage of repair and fibrosis is reached there will be no connecting bridge of callus to recalcify, and non-union will result. Even with proper immobilization for several weeks, if the fractured bones are then strained before consolidation has occurred, traumatic hyperemia results immediately. Recalcification ceases at once, decalcification supervenes, and non-union develops.

With these fundamental principles regarding the healing of fractures in mind it is urged that complete and adequate immobilization be continued until the roentgenogram reveals evidence of consolidation. Fractures of the carpal scaphoid should be completely immobilized with an unpadded plaster cast, and while the average duration of immobilization is a little over two months, occasionally it is necessary to continue for from six to twelve months. It is believed that the continued rotation movement of the upper fragment in fractures of the femoral neck results in the high percentage of non-union which is seen in these fractures. This movement may be prevented by the use of the Smith-Petersen nail, and satisfactory union obtained in from 90 to 100 per cent of these cases. In the treatment of fractures of the lower shafts of both forearm bones, immobilization is usually continued for from seven to eight weeks. This results in stiffening of the inferior radio-ulnar joint and, with the removal of the splints, movement will occur just as easily at the unconsolidated fracture of the ulna as at the inferior radio-ulnar joint. This produces repeated torsion strain in the ulnar fracture, with resulting traumatic hyperemia and decalcification and non-union. In the radius, both fragments move

together and there is no rotatory strain, and the callus continues to calcify until union is consolidated. The infected compound fracture is pathologically similar to the simple fracture, except that the initial stage of decalcification is prolonged.

J. N. ANÉ, M.D.

Fracture of the Ulna, with Dislocation of the Head of the Radius. S. R. Cunningham. *Jour. Bone and Joint Surg.*, April, 1934, **16**, 351-354.

The author is of the opinion that fracture of the ulna, with dislocation of the head of the radius, is frequently overlooked in the early stages. Since good results are usually obtained in cases recognized and treated early and since unrecognized and neglected cases result in loss of function and deformity, the diagnosis of the complication is very important.

It is believed that in all fractures of the upper half of the ulna, with displacement of the fragments, the radio-ulnar joint is of necessity involved. This condition may be the result from a fall upon the palm or thenar eminence of the hand, or from a direct blow against the extensor surface of the forearm near the junction of the upper and middle thirds of the ulna. Young workmen and children between the ages of three and twelve years were found to comprise the largest groups suffering from this injury. In the author's series of 257 cases of ulnar fracture, 14, or 5.5 per cent, had an associated complete dislocation of the head of the radius.

As a result of the upward and forward displacement of the distal fragment of the ulna, the radius is likewise directed upward and forward because of its attachment by the interosseous ligament. This results in the displacement of the head of the radius upward on the anterior surface of the humerus.

The injured arm is usually held in partial flexion at the elbow, and there is definite swelling in the upper half of the forearm and upper arm. The upper fragment of the ulna is pulled backward, and the lower fragment upward and forward. This displacement tends to fill the normal depression in front of the elbow. The head of the radius can be usually palpated in this region.

The author stresses the importance of very careful and thorough roentgen-ray examinations, with particular care to include the elbow joints, in all ulnar fractures.

J. N. ANÉ, M.D.

## GENITO-URINARY TRACT (DIAGNOSIS)

Physiology and Pathological Physiology of Dynamics of the Urinary Passageways. Maurice Muschat. *Am. Jour. Surg.*, January, 1934, **23**, 129-132.

The author feels that the dynamics of the calices have a great deal to do with stone formation in the kidney. Proper drainage of a calyx is of paramount importance. If, for one reason or another, the drainage

is impaired, stagnation will occur, with the inevitable formation of stones. Such stagnation can be caused through a topographic misplacement of the calyx, obstruction at its outlet, or through lack of muscular expulsive power to drive out the urine.

The physiologic facts, learned in the past decade concerning the dynamics of the urinary passageways, teach that no radical surgery should be done upon these organs before a careful analysis of their true function has been made. Such true facts can best be obtained by intravenous urography. There is less radical renal surgery done every day, fewer nephrectomies are performed, because it is realized how little functioning renal tissue is really needed for complete or partial renal recovery after removal of the offending cause.

As can readily be appreciated, there is very little that can be done medically to correct the deranged dynamics of these organs. Procrastination in re-establishing normal pressures within these urinary compartments will always lead to inevitable kidney atrophy and grave morbidity, which, in turn, will shorten the span of life.

DAVIS H. PARDOLL, M.D.

The Surgical Management of Bilateral Nephrolithiasis. Francis Patton Twinem. *Am. Jour. Surg.*, April, 1934, **24**, 124-128.

The author states that about 13 per cent of cases of renal stone show bilateral involvement. Bilateral stone is usually preceded by a bilateral infection. A bilateral operation should be done only in easy cases, in young subjects, and in cases in which only slight or no infection is present.

Usually the better kidney should be operated on first. Certain exceptions are mentioned.

The surgical indications in various types of bilateral stone are discussed. This type of patient requires the most meticulous care if the best results are to be obtained.

Several illustrative case records are given.

DAVIS H. PARDOLL, M.D.

Calculus Pyonephrosis: A Clinical Study, with Especial Reference to Etiology and Treatment: Review of the Literature: Report of Six Cases. I. E. Nash. *Am. Jour. Surg.*, April, 1934, **24**, 110-118.

The author briefly reviews the literature on calculus pyonephrosis. He points out that most of the cases occur in young women who marry at an early age and rapidly go through multiple pregnancies. He suggests that there may be a urinary diathesis which predisposes these women to infection and stone formation in the kidneys, analogous to those women with a biliary diathesis in whom the disease of the gall bladder is laid down at the time of the first pregnancy.

He considers the treatment of the acute and chronic type of case. For the latter, he suggests that first a nephrotomy be done, to be followed by a secondary transperitoneal nephrectomy, because the abdominal

approach enables one to avoid the hemorrhage and other complications incident to a lumbar nephrectomy.

The article is accompanied by several case reports and pyelograms.

DAVIS H. PARDOLL, M.D.

## GYNECOLOGY

Radiological Diagnosis in Metrorrhagia. Carlos Heuser. *Semana Méd.*, Aug. 31, 1933, p. 622. (Reprinted by permission from *British Med. Jour.*, Dec. 16, 1933, p. 100 of *Epitome of Current Medical Literature*.)

The author reports several cases in which, with lipiodol and very simple technic, he succeeded in demonstrating by radiography the differential diagnoses of various metrorrhagias. He found it easy to ascertain the presence of serous and placental polypi, carcinomas of fundus and cervix, and submucous fibromas, as well as to estimate quite accurately the development and progress of cases treated by radium, no matter in what part of the internal genitalia the disease lay. The ten cases he reports are illustrated by unusually clear roentgenograms, and the writer claims that without radiography correct investigation would have failed.

Diagnosis of Uterine Hemorrhages at the Age of the Menopause. J. Quénu and C. Bécère. *Bull. Soc. d'obst. et de gynéc.*, November, 1933, **22**, 742-748. Reprinted by permission from *British Med. Jour.*, June 16, 1934, page 96 of the *Epitome of Current Medical Literature*.

The authors analyze 44 cases of menopausal metrorrhagia. While 27 per cent are due to organic causes, such as carcinoma of the fundus uteri (9 per cent), fibroma, polyp, etc., they regard no less than 73 per cent as functional—of ovarian origin, either hormonal or infective. For this group they suggest the term "benign glandular hyperplasia." For all cases of menorrhagia at the menopause, they strongly advocate diagnostic curettage. Of the benign cases, two-thirds are cured by curettage without further treatment. The remaining one-third start bleeding again after a few months, and for these x-ray treatment of the ovaries is recommended to hasten the menopause.

In a subsequent paper C. Bécère further discusses benign glandular hyperplasia. Analyzing 38 more cases of menopausal metrorrhagia, he attributes 64 per cent to this condition. Microscopically, these cases show no inflammatory or neoplastic change, the uterine mucosa having the physiological appearances of premenstruation and nidation. That these are due to a modification of the ovarian hormones is borne out by the fact that if these cases are treated by x-rays to ovaries only, the hemorrhage is arrested, whereas after curettage it often recurs and continues till ovarian function finally ceases at the menopause. The clinical syndrome is: (1) abrupt onset of metrorrhagia in patients previously regular in menstruation;



(2) periods of two to three months' complete amenorrhea; (3) irregular alternation of amenorrhea and metrorrhagia. These features, in the author's opinion, further indicate the origin of the bleeding to be ovarian dysfunction, since in cases of *pathologic* changes in the uterine mucosa there is usually some previous menstrual irregularity and no such periods of amenorrhea. Although the syndrome described is characteristic of functional metrorrhagia of ovarian origin, curettage and microscopical examination of the débris is recommended, both to confirm diagnosis and to stop hemorrhage temporarily at least, pending permanent cure by the application of x-rays to the ovaries. In atypical cases hystero-graphy should precede curettage to indicate any area of the uterus particularly suspicious of pathologic change.

### THE JOINTS

Calcification in Fat Pads about the Joints. Albert B. Ferguson. *Jour. Bone and Joint Surg.*, April, 1934, 16, 418-422.

The author reports a series of four cases in which roentgenographic examination revealed flaky, calcareous deposits in the form of short rods or dashes in the region of the fat pads about the joints. As duration increased, the particles tended to appear more nodular.

Of the four cases, three gave a history of onset following trauma. In Case 1, the patient was a female, 9 years of age, who showed involvement of the left shoulder joint. Case 2, a boy, aged 16 years, revealed these deposits in the region of the right elbow joint. Case 3, a female, aged 58 years, had calcification in fat pads about the right knee. In Case 4, the patient was a female, 22 years of age, with involvement of the left knee.

Microscopic examination of sections of tissue removed surgically from two of the cases revealed fatty tissue showing masses of rather cellular cartilage, with small areas of ossification scattered through it, and traces of fat remaining between the cartilage masses.

J. N. Ané, M.D.

### THE KNEE

A Case of Tuberculous Infection of the Knee, with Clinical and Roentgenographic Appearance of Charcot's Disease. Knut Bennet and Harry Hinricson. *Jour. Bone and Joint Surg.*, April, 1934, 16, 463-466.

The patient, a male, aged 40 years, was admitted for hospitalization in September, 1931. At that time he presented a marked gibbus of the middle of the thoracic region, some affection of the left knee, and two fistulae near the upper part of the sternum. With the exception of a brother who had had a tuberculous spondylitis, the family history was essentially negative.

Ten years before admission, the patient stated, the left knee began to swell and became painful, particularly at night. The patient changed his occupation

and the pain disappeared, but the limp remained. In 1924 he was treated for tuberculous spondylitis. At this time roentgenograms of the left knee showed a normal joint space, an uneven defect in the lateral corner of the left condyle, roughened joint surfaces, and increase in breadth of the intercondylar fossa.

In 1931 the knee showed enlargement and a spindle-shaped form, with a diffusely thickened capsule, but without effusion. Roentgenograms revealed marked destruction, with sharply sclerotic borders in the tibia as well as the femur, and "several sequestral shadows of striking density, the size of an almond shell." In spite of the existence of a tuberculous focus elsewhere and the negative cerebrospinal fluid and blood Wassermann reactions, Charcot's arthropathy was considered because of the total absence of pain and the x-ray appearance of the lesion. Anti-syphilitic therapy was instituted, and with a view of producing an ankylosis to effect a cure the knee joint was resected. It was then found that the area of destruction disclosed by the roentgenogram was filled with masses containing a number of markedly sclerotic sequestra. At the back of the femur was an abscess containing caseous masses and pus-like material. Patho-anatomical examination revealed chronic inflammation of no specific character. Guinea-pig tests proved the presence of tubercle bacilli.

J. N. Ané, M.D.

### THE LARYNX

Radiation Therapy of Tuberculosis of the Larynx. J. Zange. *Strahlentherapie*, December, 1933, 48, 705-727.

The author discusses his subject at length. The productive type of the disease often responds well to x-ray therapy. Doses of from 30 to 50 per cent E.D. are recommended, and they may be repeated at intervals of from 4 to 8 weeks.

ERNST A. POHLE, M.D., Ph.D.

Malignant Disease of the Larynx and Pharynx. R. Stewart-Harrison. *Strahlentherapie*, 1934, 50, 91-126.

The author describes in detail the use of the protracted fractional dose method (Coutard) in the treatment of tumors in the larynx and pharynx. A number of case histories are given in order to illustrate the variations from the standard technic which are often necessary to suit the needs of the individual patient. In the author's opinion there is a close relationship between histology of the tumor and its radiosensitivity. Of the cases treated since 1929 in the Roentgen Institute at the University of Zürich, 144 were analyzed. Only preliminary figures can be given since no observations have been made extending over a five-year period. In 55 per cent of the patients the local tumor responded well to the treatment. A comparison is also given of the results obtained in Zürich from 1919-1928 with those obtained in other clinics. The author concludes



that the protracted fractional dose method is the method of choice for treating tumors in the epi-, meso-, and hypopharynx; it should also be considered in tumors of the larynx.

ERNST A. POHLE, M.D., Ph.D.

### PARATYPHOID OSTEOMYELITIS

Paratyphoid Osteomyelitis: A Report of Two Additional Cases. J. Ross Veal and Elizabeth M. McFetridge. Jour. Bone and Joint Surg., April, 1934, 16, 445-450.

The authors report two additional cases of paratyphoid osteomyelitis and discuss the etiology, pathology, diagnosis, and treatment of this condition.

While typhoid osteomyelitis is not usually overlooked, that form of bone disease caused by *B. paratyphosus* is generally not considered as a diagnostic possibility. Webb-Johnson, in 1,038 cases of paratyphoid fever, observed only two cases of bone involvement, both of them arthritic. Although Winslow saw 100 cases in 1916, in no case did he find any evidence of bone complication.

Paratyphoid osteomyelitis may be quite acute and accompanied by all of the usual signs of acute osteomyelitis, or it may be insidious in onset and chronic in course. While the lesions may be single or multiple, the single form is more common. Temperature, pulse, respiration, and blood count are variable as in the case of staphylococcal or streptococcal osteomyelitis.

In the early stage roentgenograms may reveal a thickening of the periosteum, which is not typical. It has been noted that the primary involvement usually is located in the diaphysis rather than at the juxta-epiphyseal region. Diagnosis depends upon the characteristic agglutination tests and identification of the organism from the blood stream or from the discharge from the bone lesion. In the cases reported by the authors the agglutination tests were positive, as was the blood culture in one case, and *bacillus paratyphosus B* was identified in the pus removed from the bones in both cases.

The treatment consists of surgical drainage when pus is present. The use of vaccine-therapy as an adjunct to surgery is considered a wise precaution.

J. N. ANÉ, M.D.

### PELLEGRINI-STIEDA SYNDROME

Calcification of the Tibial Collateral Ligament: A Report of Forty-two Cases. Jerome G. Finder. Jour. Am. Med. Assn., April 28, 1934, 102, 1373-1375.

The first case was reported in the English literature in 1933, previous to which 150 cases had been recorded in European publications. Köhler (1903), Pellegrini (1905), and Stieda (1907) were the first to report and study the disease. Roentgenograms reveal a semilunar shadow overlying, but usually distinctly separate from, the medial femorocondylar angle. Depending on the degree of ligamentous involvement, the shadow

may be crescentic, triangular, or fusiform. It may be limited to the condylar region or extend distally toward the joint. The author also describes three other groups showing: central areas of calcification, a pea-sized nodule in the mid-portion of the ligament; combined areas of calcification, combining characteristics of Groups 1 and 2, and irregular areas of calcification. Injury is almost invariably the inciting factor. Conservative measures are usually advocated; rest during the acute stage, physical therapy later.

C. G. SUTHERLAND, M.D.

### PEPTIC ULCER (DIAGNOSIS)

What Causes Peptic Ulcer? Editorial. British Med. Jour., April 21, 1934, No. 3824, 719, 720.

A large variety of theories of the causation of peptic ulcer has been advanced, such as infection, interference with blood supply, trauma, allergy, vitamin deficiency, and disturbance of endocrine function. Those hypotheses based on experimental evidence are considered weak, as the type of ulcer produced experimentally has usually been acute, superficial, and rapidly healing, whereas we are more concerned with the type of ulceration which has as essential features deep destruction and a most persistent chronicity. However, Mann and Williamson produced these chronic ulcers experimentally. These workers believed peptic ulceration occurred only in areas of mucosa exposed to the action of acid gastric secretion, and they were able to induce persistent ulceration beyond the pylorus by diverting the alkaline secretions which normally neutralize the gastric contents at this point.

Florey and Harding showed that the duodenal mucosa plays an important rôle in neutralizing acid from the stomach, and believed that an insufficiency of this secretion may be a factor in producing peptic ulceration. These experiments have all been repeated many times by other investigators, with the same findings. This fact, with the constant finding of hyperchlorhydria in the subjects of this disease, would indicate that the chief factor in maintaining peptic ulceration is the local action of gastric secretion.

With the weight of evidence already on hand pointing to the local action of the gastric secretion, it is considered a little surprising to find it seriously suggested that peptic ulcer is due to a specific infection. Saunders, Holsinger, and Cooper, in a recent publication, reiterate the original findings of Saunders to the effect that a constant and distinct type of streptococcus can be cultivated from peptic ulcers, and adduce evidence that feeding cultures of this streptococcus to dogs subjected to one of the surgical procedures devised by Mann and Williamson increases the subsequent incidence of ulceration and alters its type. While it is not inconceivable that a strain of streptococcus may multiply in the base of a preformed ulcer and even give rise to agglutinin formation, this would not prove that this particular type of organism produced the ulcer.

J. N. ANÉ, M.D.

### THE PROSTATE

Prostatic Resections, with Special Reference to Poor Surgical Risks. A. E. Goldstein and Charles S. Levy. *Am. Jour. Surg.*, March, 1934, **23**, 452-456.

In the hands of the experienced, this is a logical surgical procedure for selected cases, principally small lobes and vesical contracture. The authors reached the following conclusions regarding their experience with prostatic resection.

Good surgical risks with very large prostatic adenomas should be prostatectomized. Poor surgical risks, regardless of the size of the prostate, are best amenable to prostatic resection.

The operative procedure of prostatic resection can be performed on poor surgical risks with greater safety than can the open operation.

On poor surgical risks with prostatic obstructions one should do prostatic resections rather than resort to a catheter or suprapubic tube life for the patient.

DAVIS H. PARDOLL, M.D.

Prostatectomy with Closure: Five Years' Experience. S. H. Harris. *British Jour. Surg.*, January, 1934, **21**, 434-452.

The article presents the author's results obtained during the five years' currency of this operation. The number of cases submitted to prostatectomy was 371; deaths 10; mortality rate 2.7 per cent.

The operation is decidedly not one for the occasional prostatectomist, but the technic will present no insuperable difficulties to those experienced in this branch of surgery. The essential features of the operation are the immediate control of hemorrhage by suture, the re-formation of the prostatic urethra, and obliteration of the prostatic cavity, combined with immediate closure of the bladder and abdominal wound.

In addition to the improvement of mortality, morbidity, and operability rates, manifested by this operation as compared with other widely practised methods of suprapubic prostatectomy, this operation also completely obviates post-operative recurrence of obstruction. Further, the various septic manifestations, which have been the bugbear of prostatectomy, have almost completely disappeared.

DAVIS H. PARDOLL, M.D.

### THE SKIN

Quality of Radiation and Skin Reaction. G. Schwarz and A. Frank. *Strahlentherapie*, 1934, **50**, 145-156.

The influence of the quality of radiation on the skin reaction was studied on human skin (thigh). The following qualities were used: 178 K.V., 0.5 mm. Cu + 2 mm. Al, H.V.L. in Cu = 0.95 mm.; 160 K.V., 0.5 mm. Cu + 1 mm. Al, H.V.L. in Cu = 0.737 mm.; 120 K.V., 1 mm. Al, H.V.L. in Cu = 0.13 mm.; 110 K.V., 1 mm. Al, H.V.L. in Cu = 0.133 mm. Since "threshold" erythema and erythema of first degree

are difficult to define the authors chose a marked reaction, *i.e.*, dermatitis sicca and exudativa. This necessitated the administration of high doses in a single sitting (1,600 r). All factors remained the same in the exposure of two comparative fields except the wave lengths. For instance, one experiment was conducted under the following conditions: right thigh received 1,600 r at 160 K.V., 0.5 mm. Cu + 1 mm. Al, 3 ma., H.V.L. in Cu, 0.74 mm., 40 r per min., 20 cm. F.S.D. The left thigh received 1,600 r at 110 K.V. through 1 mm. Al at 2 ma., H.V.L. in Cu, 0.13 mm., 40 r per min., 20 cm. F.S.D. The applied dose was controlled by means of an integrating dosimeter during the entire length of the exposure. Photographs are appended showing the reactions at various intervals after the treatment, up to 72 days.

An analysis of the results shows that the roentgen dermatitis was much more pronounced if harder rays or, in other words, radiation of shorter wave length was used. The authors emphasize that these results contradict the viewpoint that roentgen rays are the most injurious to the skin the softer they are.

ERNST A. POHLE, M.D., Ph.D.

Ointments for Protection against Light Exposure. Richard Hahn. *Strahlentherapie*, 1934, **49**, 181-222.

The author tested with physical and biologic methods the efficacy of 29 ointments sold in Germany for protection against sunburn. He found that seven of the ointments served the purpose very well, but that better preparations must be developed. For details, see the numerous tabulations and graphs in the original article.

ERNST A. POHLE, M.D., Ph.D.

### THE SKULL

The Pineal Body: Roentgenological Considerations. Jacob H. Vastine. *Am. Jour. Roentgenol. and Rad. Ther.*, August, 1933, **30**, 145-155.

The function of the pineal body is still a subject of much controversy; however, what is of great importance to roentgenologists is that it becomes sufficiently calcified for roentgenologic visualization in a large percentage of cases in adults (52 to 60 per cent of adults over 20 years, and 15 to 20 per cent of individuals under 20). When calcified and thus visualized it may be shown to be displaced either by tumor or by trauma, with intracranial hemorrhage. Sources of error in considering displacement are: (1) improper positioning of patient with resultant imperfect lateral or anteroposterior films being obtained; (2) unusual skull shape, particularly dolichocephaly; (3) unilateral calcification in the falx cerebri; (4) calcification in tumors near the pineal, with the pineal not calcified; (5) areas of calcification due to psammoma, phleboliths, etc.

The writer discusses pineal tumors and warns against the use of encephalography because of increased intracranial pressure. These tumors are rarely localized

ante-mortem, and, similarly, they have rarely been reported as showing roentgenologically demonstrable calcification.

J. E. HABBE, M.D.

The Roentgen Findings in Suppuration of the Petrous Apex (Petrositis). Henry K. Taylor. *Am. Jour. Roentgenol. and Rad. Ther.*, August, 1933, **30**, 156-162.

Suppuration in the apical portion of the petrous pyramid is a complication of an acute otitis, and can be recognized clinically and roentgenologically. Clinically, there is profuse otorrhea occurring after a period of cessation, following a simple mastoidectomy, pain along the distribution of the ophthalmic branch of the fifth nerve, and low grade sepsis. Roentgenologically, by infero-superior projection of the base of the skull one may see diminished aeration, deficient trabeculations, atrophy, perforation, and finally destruction of apical contour. The illustrations show clearly the pathological changes described by the author.

J. E. HABBE, M.D.

## THE SPINE

The Roentgen Diagnosis of Spinal Deformities. M. L. Sussman and M. A. Kugel. *Am. Jour. Roentgenol. and Rad. Ther.*, August, 1933, **30**, 163-176.

All spinal deformities examined roentgenologically should be studied with regard to shape of intervertebral discs, presence of bone reaction, presence of general atrophy of spine, and manifestations of disease elsewhere, as well as the shape and appearance of the vertebræ proper. Deformities are classified by the authors into the following groups: congenital, developmental, traumatic, infectious, metabolic, blood dyscrasias, primary tumors, metastatic tumors, pressure atrophy and unclassified (Hodgkin's disease). According to the authors, a longitudinal diameter of a vertebra shorter than the corresponding diameter of a vertebra above it is to be considered as absolute evidence of pathologic involvement of that smaller vertebra, congenital anomalies excluded. The presence of a localized hypertrophic arthritis with wedging of the body and without narrowing of the discs is considered usually to indicate an old compression fracture. The Kümmell-Verneuil syndrome is traumatic collapse of a single body, with a general malacia of the spine in addition. The characteristic appearance of osteomyelitis (staphylococcus, pneumococcus, meningococcus, *B. typhosus* or *paratyphosus*, *melitensis*, or *proteus*) is a localized ragged hypertrophic spondylitis, with uniform narrowing of the adjacent intervertebral disc and slight wedging of the body, progressing later to collapse, often with destruction of the vertebral appendage. Metabolic disorders (amyloid disease, the xanthomatoses, and possibly Niemann-Pick's disease) give characteristically a narrowing of the vertebral body with either wedging as a lenticular shape, with either no change or a widening with

spherical shape of the disc. A similar appearance is seen in Paget's and von Recklinghausen's disease.

A large tabulation is appended showing the frequency of changes in the bodies, discs, and appendages, in the various conditions described.

J. E. HABBE, M.D.

Roentgen Observations in Vertebral Osteomyelitis and Spondylitis Infectiosa. H. Sternberg. *Fortschr. a. d. Geb. der Röntgenstrahlen*, 1934, **49**, 32-56.

Roentgenologic, clinical, and pathologic findings in non-tubercular inflammatory conditions of the spine are discussed, especially subacute benign vertebral osteomyelitis and chronic infectious spondylitis. The following clinical entities are considered separately: Acute vertebral osteomyelitis, chronic vertebral osteomyelitis, subacute vertebral osteomyelitis, acute infectious spondylitis, chronic infectious spondylitis. Each clinical entity is illustrated with case reports. Then follows the résumé of the observations and a review of the pathologic anatomical basis for the clinical conception. Finally, the differential diagnosis between vertebral osteomyelitis, infectious spondylitis, and tubercular spondylitis is discussed with some detail.

It is stated that acute vertebral osteomyelitis, while rather rare, always presents a very serious disease, with a poor prognosis on account of the early extension of the infection to the meninges. While an early diagnosis might lead to sufficiently early surgical interference, roentgenologic symptoms cannot be found sufficiently early, and even in subacute cases it requires from three to eight weeks before vertebral destructive processes can be demonstrated roentgenologically.

Concerning chronic vertebral osteomyelitis very few reports are found in the literature. Statements repeatedly made by Oehlecker concerning chronic vertebral osteomyelitis are emphasized, that "it is important to investigate more carefully so-called cases of tubercular spondylitis, which show formation of ridges, bridges, and spurs or a striking sclerosis of bone." Not infrequently such cases should be diagnosed roentgenologically as chronic vertebral osteomyelitis of non-tubercular etiology. The case illustrating this clinical picture, demonstrating a chronic streptococcus-spondylitis at two levels of twelve years' duration, finally terminating with amyloidosis, also was considered and treated for long periods as a tubercular spondylitis. Subacute spinal osteomyelitis is characterized by an acute onset but leads to complete cure during a relatively short time. During the progress of the disease there occurs first a very marked demineralization of the affected portion of the vertebra, later a correspondingly extensive collapse, ultimately good regeneration of the deformed vertebral segment, at times with a varying degree of sclerosis. Large paravertebral abscesses may develop and undergo complete absorption.

The most interesting part of this paper concerns acute and chronic infectious spondylitis. These terms are interpreted as spondylitis occurring in connection with acute infectious diseases. Such vertebral disease very

regularly leads to symptomless or nearly symptomless recovery, especially the acute infectious spondylitis. Roentgenologically, one can observe shortly after the onset of the disease, which, as stated, always follows an acute infectious disease, limited destructive processes in the terminal plate of the vertebra or in adjacent spongy bone. This infectious process soon involves the intervertebral disc, which regularly undergoes narrowing. Healing of the infectious process starts soon with production of extensive reactive osseous spurs and ridges, which usually bridge over intervertebral discs and thus immobilize spinal segments. Such bony overgrowth in time may undergo much partial reabsorption.

Chronic infectious spondylitis in its roentgenologic manifestations resembles a milder degree of the acute disease and is discovered usually without any clearly shown connection to an acute infectious disease. It is said that the chronic infectious spondylitis is characterized by the fact that long periods, often years after an acute infectious disease, complaints concerning the spine are registered. On close inquiry it is not infrequently found that during the acute infectious disease pain in the back of considerable severity was observed during a short period, or that a "muscular rheumatism" developed following such an infection. Roentgenologically one finds an isolated reduction in height of an intervertebral disc, condensation of an adjacent vertebral portion, and some, at times fusing, paravertebral ridges and spurs. No evidence of generalized chronic *deforming* spondylitis was observed in such patients, the disease always being limited to one segment.

Differential diagnosis on a roentgenologic basis, especially toward tubercular spondylitis, is often quite difficult. Errors are especially possible between osteomyelitic foci and tuberculosis in the central portion of the vertebral body—primary osseous form of tubercular spondylitis. Oehlecker considers appreciably sclerosis of the vertebrae, with formation of paravertebral ridges and spurs, as characteristic for non-tubercular disease, but other authors have pointed out that occasionally such paravertebral ridges and spurs may also develop in cases of healed tubercular spondylitis, though such instances may be relatively rare.

This article should be read in detail by all those interested in traumatic and infectious diseases and especially by the men doing an appreciable amount of compensation work.

HANS A. JARRE, M.D.

Roentgenological Studies of the Intervertebral Disc: A Discussion of the Embryology, Anatomy, Physiology, Clinical and Experimental Pathology. Edward L. Compere and Donald C. Keyes. Am. Jour. Roentgenol. and Rad. Ther., June, 1933, 29, 774-797.

The authors' experience confirms Schmorl's observation that the commonest lesion of the spine is prolapse of the nucleus pulposus into the spongiosa of the vertebral body. Pain or disability does not immediately follow such prolapse, although eventually, if loss of the semigelatinous fluid is extensive, a dehydration of the

disc follows, with resultant loss of the hydrodynamic function, which, in turn, causes increased stress on the bone and probably causes the lipping or osteo-arthritis commonly observed. Any pathologic process which weakens the structures confining the nucleus pulposus, invades the nucleus or merely allows a portion of the nuclear material to escape, will interfere with normal spine function. There are no nerve fibers in the disc structure, hence subjective symptoms from involvement of the disc by trauma or disease are in proportion to the degree of involvement of adjacent structures. Cases of single and multiple nuclear prolapse, of calcification of the nucleus, or metastatic sarcoma, tuberculosis, extensive degenerative arthritis, of compression fracture, and of juvenile kyphosis are all described, to show the primary and secondary changes demonstrable in the intervertebral disc. The illustrations include roentgenograms, museum specimens, sketches, and photomicrographs.

J. E. HABBE, M.D.

## THE STOMACH

Absence of Left Diaphragm Associated with Inverted Thoracic Stomach. Zachary Sagal. Am. Jour. Roentgenol. and Rad. Ther., August, 1933, 30, 206-214.

Only eight cases of thoracic stomach have been reported in the literature. The most serious error (which may result fatally if thoracentesis is attempted) is in making a diagnosis of hydropneumothorax when actually one is dealing with thoracic stomach. The case reported by the author is that of a male, aged 39, who first developed acute attacks of vomiting and marked thoracic compression at the age of 33. There had been only slight dyspnea on extreme exertion, prior to this date. Physical examination showed distant breath sounds and a few râles in the left apex, with all of the classical signs of hydropneumothorax on the left side. At that time a diagnosis of hydropneumothorax and presumptive pulmonary tuberculosis was made, although aspiration of the left chest had been twice unsuccessful. When examined later by the author a condition closely simulating hydropneumothorax was seen, but without evidence of compression of the left lung. The stomach was aspirated and on re-examination no fluid level was seen, the gas accumulation was much lower, and the lung appearance in the upper chest was more normally clear. The left diaphragm could not be seen. When barium was given by mouth the stomach was found to lie in the left chest in an inverted position, the cardia being low and the pyloric end high up, the pylorus and proximal duodenum lying mesial and posterior to the cardia. Later study showed the upper part of the left side of the colon to be also in the left chest. The recurring acute attacks during adult life were attributed to a volvulus of the stomach which untwisted itself with certain changes in position of the patient or under the influence of a narcotic. There had been only four acute attacks in six years.



Warning is given against performing a thoracic paracentesis in the presence of a chest condition which appears to be atypical hydropneumothorax, without first determining by means of a barium meal, the location of the stomach and intestines.

J. E. HABBE, M.D.

### SPONDYLOLISTHESIS

Spondylolisthesis in an Infant. Samuel Kleinberg. *Jour. Bone and Joint Surg.*, April, 1934, **16**, 441-444.

While it is generally believed that the basis for spondylolisthesis is a congenital bilateral osseous defect in the pedicles between the superior and inferior articular processes, it is also believed that the actual dislocation occurs during adolescence, or adult life. About half of the cases with this condition of the spine give a history of sufficient trauma to tear or stretch the fibrous band bridging the defect, but many cases give no history of injury.

The author reports the case of a baby, 17 months old, admitted to his clinic for treatment for congenital dislocation of the left hip. Routine x-ray examination showed marked spondylolisthesis, with the body of the fifth lumbar vertebra displaced forward on the body of the sacrum to a distance of more than half of its anteroposterior diameter. The anteroposterior view showed also bilateral vertical laminar defects.

The author believes that the discovery of this case of congenital spondylolisthesis makes it likely that others are also congenital and necessitates a more careful and critical study of this type of deformity in relation to its exact onset, particularly in the absence of a history of a definite injury or sudden appearance of subjective symptoms.

J. N. ANE, M.D.

### THE THORAX

Trauma as an Etiological Factor in the Production of Diseases of the Chest. L. R. Sante. *Am. Jour. Roentgenol. and Rad. Ther.*, July, 1933, **30**, 8-15.

Pneumothorax following injury to the chest wall is usually associated with demonstrable rib fractures; occasionally, however, it follows injuries without evidence of bony trauma. Similarly a dry pleurisy followed by pleural thickening may follow injury with or without a fracture. Such pleural thickening can be demonstrated roentgenographically but not differentiated from pleural thickening of inflammatory origin.

Ordinarily penetrating wounds (stab or gunshot) are not serious unless infection supervenes or associated injury to the heart or abdominal organs takes place at the same time.

In only one condition does bacterial disease of the lungs seem to occasionally follow trauma—this is the so-called "traumatic pneumonia."

Massive collapse of the lungs may occur following trauma to the chest wall or remote portions of the body.

In general, it may be concluded that any bacterial infection of the chest related to trauma is probably on the basis of a lowering of the patient's general resistance incident to trauma.

J. E. HABBE, M.D.

### TUBERCULOSIS (SURGICAL)

An Inquiry into the Results of Surgical Treatment of Genital Tuberculosis in the Male. Ralph O. Lee and Kenneth Bowes. *British Jour. Surg.*, January, 1934, **21**, 456-460.

The authors followed up and analyzed a series of 89 cases of genital tuberculosis in the male, occurring in a ten-year period.

The mortality of the disease appears to be about 20 per cent. Upward extension of infection to the urinary tract is rare. The recurrence rate after surgical interference is about 40 per cent, this figure not being influenced by the presence of a palpable vesicle before operation, nor by its surgical removal.

Radical operation with vesiculectomy, while not affecting the recurrence rate in the other epididymis, seems to decrease the remote mortality. In this series, radical operation has introduced an immediate mortality.

DAVIS H. PARDOLL, M.D.

### TUMORS (DIAGNOSIS)

Adamantinoma of the Tibia. Edgar Holden, Jr., and John W. Gray. *Jour. Bone and Joint Surg.*, April, 1934, **16**, 401-417.

The authors report a case of adamantinoma of the tibia which occurred in an unmarried female school teacher, 36 years of age. The patient complained of pain and swelling of the left lower tibia of about two years' duration. There was a history of trauma just before the onset of the pain. With the exception of a localized swelling over the lower tibia, the physical examination was essentially negative. The urinalysis and blood counts were normal and the Wassermann was negative. X-ray examination showed the presence of a destructive lesion 5 cm. by 3 cm. in size in the lower end of the tibia. It had somewhat the appearance of a multilocular cyst, with the margins sharply delineated but not thickened. The entire diseased area was removed at operation and sections studied microscopically. The pathologic diagnosis made at this time was adenoma malignum.

Following the operation the patient remained well for about two years, when, after "turning the left ankle" pain and swelling recurred. Roentgenograms showed evidence of recurrence of the original tumor. The pathologic area was again removed surgically and the cavity curetted and chemically treated. The patient was then referred for x-ray therapy. The microscopic examination of sections of tissue removed at the second operation showed an infiltrating epithelial growth in a fibroblastic stroma. The pathologic diagnosis at this time was adamantinoma.



The adamantinoma is an epithelial tumor, fundamentally basal-cell in type, in which all degrees of differentiation of the enamel organ can be found. The tumor develops from: (1) the paradental debris, (2) the oral epithelium, and (3) the enamel organ. Cystic formation in the central network of the epithelial groups is almost a constant microscopic observation of adamantinomas.

Extramaxillary adamantinomas are considered uncommon. Such tumors occurring at the base of the skull have been reported and their origin traced to remnants of buccal epithelium in the neighborhood of the pituitary gland. The very rare adamantinomas of the tibia represent the only other location of these tumors extramaxillary.

J. N. ANÉ, M.D.

### THE UTERUS

Recurrence in Carcinoma of the Uterus. Felix Gál. *Strahlentherapie*, 1934, 50, 127-144.

The author groups the recurrences observed in uterine carcinoma as follows: recurrence after total hysterectomy, continued growth of microscopically small tumor cells left after radical operation, further growth of carcinoma particles seen at operation but not removable, growth of carcinoma particles distant from the field of operation, recurrence in carcinoma apparently healed by radiation therapy, recurrence in carcinoma after complete healing following radiation therapy. During the period from 1922 to 1931, 204 patients with recurrences, who had been operated on somewhere else, and 48 of 206 patients with recurrences operated on in the author's clinic were observed. The treatment of these recurrences consisted of combined roentgen and radium therapy. The 48 cases from the author's own clinic are studied in detail. Of 125 carcinomas of the portio, 32 (or 25.6 per cent) recurred. The respective figures for 14 carcinomas of the cervix were 8 (or 57 per cent), and for 52 cases of carcinoma

of the fundus, 8 (or 15 per cent). Four (or 8.9 per cent) of these recurrences remained well over five years. At intervals of five weeks they received 50-60 mgm. radium element for a period of 24 hours. One "carcinoma dosis" of roentgen rays was added. There was apparently no relation between the histologic structure of the tumor and the frequency of recurrence.

He also analyzed the 206 of his own patients as to the efficacy of the various treatment methods. It appeared that out of this group of cases who had radical operation, 28 were treated by radium prophylactically. Ten (or 35 per cent) recurred. Fifty received x-ray plus radium and 15 (or 30 per cent) had recurrence. One hundred twenty-eight were treated prophylactically by roentgen rays before operation and 23 of these (or 17.9 per cent) developed a recurrence. It seems, therefore, that prophylactic x-ray therapy gives the best results. A number of selected case histories are found throughout the article to illustrate some of the author's observations. In conclusion he briefly discusses the fundamental difference between the surgical and radiological treatment of uterine cancer and its influence on the organism as a whole.

ERNST A. POHLE, M.D., Ph.D.

### VARICOSE VEINS

Venography in Varicosities of the Lower Extremities. S. Chodkewitsch and A. Laskarew. *Fortschr. a. d. Geb. d. Röntgenstr.*, 1934, 49, 143-147.

This is a brief technical description of the method and an only too short demonstration of the different types of varicosities encountered. The value of the method for determination of the type of desirable treatment is stressed (from 5 to 10 per cent sodium iodide, usually 20 c.c., occasionally more or less). Serial films are made during and after injection and with change of posture. Occasional thromboses were observed.

HANS A. JARRE, M.D.

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